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Adjuvantibus

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DATA ON THE GEOLOGY AND MINERALOGY OF THE OIL SHALE OCCURRENCE AT PULA, HUNGARY

J. MEZŐSI and M. MUCSI

SUMMARY

The gravelly sand of basaltic and basalt tuff substance forming the basement of the oil shale and the overlying alginite was taken stratigraphically one rhythm. So the sequence overlies directly the erosion surface of the Upper Triassic dolomite. In its roof carbonate mud, humic clay and aleurite are found.

The oil shale is of rhythmic structure locally with thick (several metres) "massive" oil shale intercalations.

The lower ten metres of the bore Put—7 is alginitic carbonate mud of massive type with a few coalified plant remnants. The ostracod half-shells and Diatoma-skelets are frequent. This is overlain in about 10 m thickness by carbonate-muddy alginite of inhomogeneous structure with the remnants of Botryococcus colonies and diatoma-skelets. Above it thin aleurite intercalation is found which is followed by alginite of massive type down to 15 m and this is replaced by clay marl and sandy aleurite of 1 to 1.5 m thickness. Between 8 and 13 metres alginitic aleurite, aleuritic alginite and carbonate mud alternate, then carbonate mud and clay marl, finally clayey aleurite follow.

The formations are for the most part built up by minerals of predominantly micron size, thus these were determined by means of X-ray diffractometer. The percentual determination of the individual phases was impossible just because of the locally widespread amorphous material.

The frequent minerals of the bore's formation are as follows: aragonite, calcite, dolomite, quartz and locally feldspar, and clay mineral also frequently occurs. In the lower section of 20 metres aragonite plays a predominant role. Small quantities of calcite, dolomite are characteristic, the quartz is sometimes absent, the feldspar is subordinated. Between 20 and 5 m three smaller sections can be separated where aragonite is absent and is replaced by calcite and dolomite.

It has been determined that in spite of its instable structure aragonite may remain when the enclosing rock is clayey, less permeable, or oil shale. In our case both criteria exist.

The possibility of formation of aragonite is explained by the fact that the lagoon enclosed by the ring-shaped tuff barriers of the volcanic crater had been heated by the subsequent hot springs so there was a possibility to $CaCO_3$ to precipitate in form of aragonite.

In the bore the periodical occurrence of aragonite and the change in the mineral composition are explained by the fact that this lake of warmer water was periodically inundated by colder water of higher salt concentration from outside. During these phases the precipitation of aragonite ceased, the grain size of the sediment changed and quartz becomes predominant, in general.

INTRODUCTION

The area of Hungary is covered by Neogene and Quaternary basin formations in about 85 per cent. Their average thickness is 1500 metres, in extreme cases these may amount to 5,000 metres, too. Their formation characterizes the evolution of the Paratethys region, *i. e.* the older Miocene formations are of normal haline shallow water origin. The Upper Miocene is of brackish sequence, the Pannonian formation is brackish-fresh and makes evident the deposition in shallow water. The Quaternary formations are mostly of freshwater and eolian terrestrial origin. The oil shale formation investigated in the strata sequence of the bore Put—7 in Pula is assigned to the middle sequence of the upper part of the Pannonian sequence which can be assigned to the Pliocene after the international stratigraphic scale. Its appearance is connected with small-sized basalt crater formed within the intramountain lagoon (Tapolca — Nagyvázsony Basin) of the Bakony Mountains, *i. e.* of the southwestern members of the Transdanubian Central Mountains, and this is the filling material of this crater [Á. JÁMBOR, G. SOLTI, 1975].

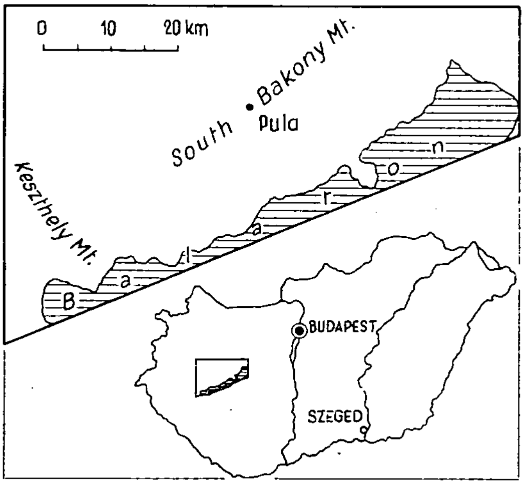

Fig. 1. Plan of the bore

To carry out the laboratory investigations on the samples of the prospecting bore Put—7 settled in 1975 for the survey of the oil shale instructions were given by the Hungarian State Geological Institute to the Department for Mineralogy, Geochemistry and Petrology of the Attila József University. From the cores sampling was carried by every half metres. To evaluate our investigations the strata sequence of the bore was obtained by researchers of the Hungarian Geological Institute (Budapest).

According to this, the oil shale series (alginitic sequence) together with its sedimentary cover and gravelly-sandy floor of basalt tuff substance can be imagined as a rhythm of medium size, its total thickness hardly surpasses 50 metres. The sequence directly overlies the erosion surface of the Upper Triassic dolomite.

The oil shale series is of rhythmic built-up. On the basis of the investigated strata sequence of the bore Put—7 it can be divided into subrhythms, in certain sections into series, moreover into layer pairs of annual formation. The size and order of magnitude of the subrhythms may be rather different. In the upper boundary and final stage of the subrhythms sections and intercalations of oil shale substance can be repeatedly observed which are thin and of several, max. 10 cm thick in general, and which consist of mostly brown-coloured, parallel, macroscopically homogeneous lamellae of hundredth or tenth mm thickness. The series built up by these layer pairs remains unchanged just after drying the sample occasionally foliation or separation can be observed in the sample's margin. These parts accumulated during a relatively long time under undisturbed conditions and contain rather small quantities of non-combustible material. High C_{org} values can be expected in them, much higher than determined in the average samples. Their porosity, permeability, bulk density and carbonate content are low. Their total thickness within the sequence is insignificant.

In case of another textural type the colour and material quality is the same the only difference is that the thin-lamellated structure cannot be observed by eyes and separation can be hardly observed. This subtype is characterized by relatively higher porosity and permeability, the bulk density and carbonate content is low.

When describing the core samples massive, lamellar and "shoe sole" texture types were distinguished, after G. SOLTI.

"Massive" oil shale or alginite. The term "massive" is suggested by Á. JÁMBOR. Macroscopically this oil shale type is unstratified, along the distinctive boundaries are separation traces, at least. Within the sequence it can be stated as a general tendency that the unstratified oil shale is relatively of coarser grain size composition (the aleurite and fine-sand fractions are characteristic). As to our opinion, on the basis of the textural and structural similarities the term "massive" can be used also in the case of alginitic marl, alginitic carbonate mud. It is to be emphasized that within the oil shale sequence the unstratified parts are thinner than 10 m in every cases.

Thin-stratified oil shale type. It is characterized by the frequent alteration of 0.1 to 5.0 mm thick lamellae of different colours of green, white and pale-grey. The "shoe sole" type occurs rarely and only in the upper part of the sequence. The dark-brown colour and the transparent paper-likely flexible lamellae are characteristic.

Carbonate mud. It was found in the upper part of the sequence resp. above the alginite, as well as in the bottom of the sequence. The upper "marl" and the completing "alginitic" marl are of low diagenetic degree, thus the term carbonate mud refers better to the consistency of the rock, to the conditions of formation as well as to the mixed-carbonate mineral composition (see later). In the bore Put—7 the role of Algae changes in well observable manner and replaced gradually by chemical processes during sedimentation. The term carbonate mud was used in case of several samples from which no material had been analyzed, in these cases the local macroscopic description was re-evaluated.

It is considered to be important to determine the quality of stratification since among others conclusions can be drawn to the state of movement of sedimentation medium, *i. e.* to the environment of accumulation. The sediments of undisturbed waters into which the alginites can be assigned, resp. its layers are parallel with one another and often but not always with the layer surfaces determining the form of accumulation.

The layers of the investigated sequence have two members in general, thus pair-lamellation can be spoken of. In their macroscopic description the terms "thin-stratified" or "of lamellar formation" were used. The paired lamellar formation is characteristic of the rock where one of the members — almost without exception the upper member — is of subordinate thickness. Since their material quality is different, the observable parting is found here.

Regarding the relation of the thin lamellae, the type of parallel formation, within this the simple, lamina-structure predominate; the gradated and homogeneous formation of the layers is less frequent *(Fig. 2)*.

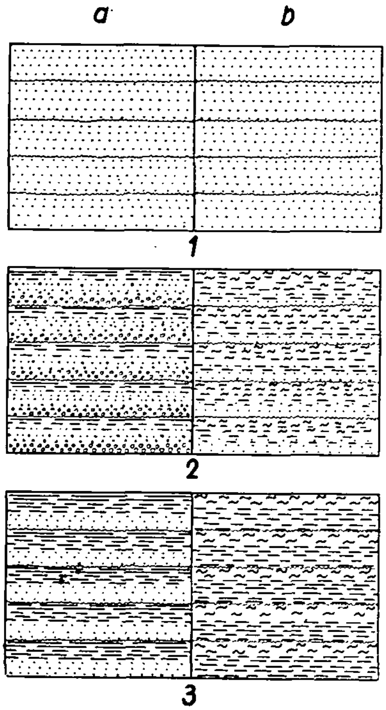

Fig. 2. Structure of the laminae and lamina pairs (Applying the data of Botvinkina, Allen and others).

Legend: the marks used do not relate by all means to material quality.

a) theoretical types, *b)* formation characteristic of the material investigated.

1. Homogeneous lamina. Along the separating line the material quality may be different as thin intercalation, at the same place parting can be occasionally observed.
2. Gradated lamina-paired structure. Oriented and gradual change in material quality and grain size within the lamina paisr, at the boundary of the lamina pairs parting can be observed.
3. Banded "paired lamina pair" of double structure. No gradualness can be observed at the boundary of pairs, the laminae are separated, parting is frequent at the boundaries. Lamina pairs are repeated several times, occasionally in sections of greater thickness these are constant; in this sense the lamina pairs are homogeneous resp. the rate and course of sedimentation are rhythmic.

To classify the stratified sediments the thickness of them is often used. Referring to literature data, below 3 mm thickness very thin lamellae, between 3 and 10 mm thin lamellae, between 10 and 30 mm moderately thick layers are mentioned [*e. g.* L. N. Botvinkina, 1965].

According to the classification the thin-stratified sections of the alginitic sequence the very thin lamellation is characteristic. In our descriptions, since the annual periodicity is probable in numerous cases, further distinctions are used: the thinnest lamination is of hundredth mm size, within the oil shale sequence the lamina of tenth mm size are most frequent.

No distinction was made between the thin-lamellated (3 to 10 mm) and medium thin-lamellated (10 to 30 mm) formations since these types were observed in negligible quantity within the investigated sequence. Above the thickness values listed above (i. e. above 3 mm) uniformly the term lamellar in cm size (or thin-stratified) was used.

The oriented grain size change which could be observed occasionally in the lamina and stratum members is called gradation.

STRATA SEQUENCE AND TEXTURAL PECULIARITIES IN THE BORE PUT—7

The bottom of the bore: 55 m. The outlined strata sequence and stratification (certain textural features) of the bore Put—7 is shown in *Fig. 3*.

53.2—(55.0) m. The oldest layer reached in the bore is of Upper Triassic age and is grey dolomite with calcite veins.

39.3—53.2 m. The dolomite is overlain by basalt tuff lapilli, basalt tuffite and basalt-sand with basalt pebbles (39.3 to 41.8 m). The dip of the members decreases from down, at 39.3 m the contact with the alginitic sequence lies in a sharp boundary.

30.0—39.3 m. Alginitic carbonate mud. It is of "massive" type. It is of light greenish-grey colour, locally darker-coloured section can be observed, the change of colour is continuous and can be assigned to relatively finer grain size and to intercalations of higher clay content.

The formation is uniform, parting is rather infrequent and in these cases no special change in the material quality can be observed (Plate I., photos 1—4.). On the basis of parting the dip of the upper part of greater thickness is only several degrees, the lower is of 5 to 15° dip.

In the case of some greater samples parting can be observed along steep-dipping or vertical planes, the dark-green coloured, bright, clayey coat of the parting surfaces between 38.0 and 38.5 resp. 33.5 and 34.0 m relates to displacement.

The rock contains small number of coalified plant fragments, rarely the impression of a leaf of deciduous trees and monocotyledonous stems occur, the latter ones bound to parting surfaces. The ostracod half-shells are frequent (Plate I, photo 1). Only the fragments of mollusc shells were observed.

Disturbed bedding (*e. g.* micro-folding, clay pebbles, etc.) was not observed. In the slides prepared perpendicularly of the parting surface slight orientation was found (Plate I, photo 3), but annual or other rhythmicity which could be connected with precipitation of sediment transport could not be observed. In the textural pictures, especially under higher magnification, the spot-like appearance of the organic matter can be fixed, but regarding the section of about 10 metres its distribution is uniform. Within this section the uniform distribution of carbonate content relates to the regularity of material supply. The porosity of the rock is high (about 40 per cent), its bulk density is of medium measure. Diatom shells are frequent.

26.0—30.0 m. Strongly carbonate-muddy alginite. It is of "lamellar" formation. According to the change of stratification and material quality the colour of the rock is green, light-green, off-white, white. Change of colour could be occasionally observed also within the lamina pairs. The well-defined green colour occurred in the parting surfaces.

The rock is inhomogeneous. The thickness of the lamina pairs extends from tenth to several millimetres, the latter ones are of similar quality than the former

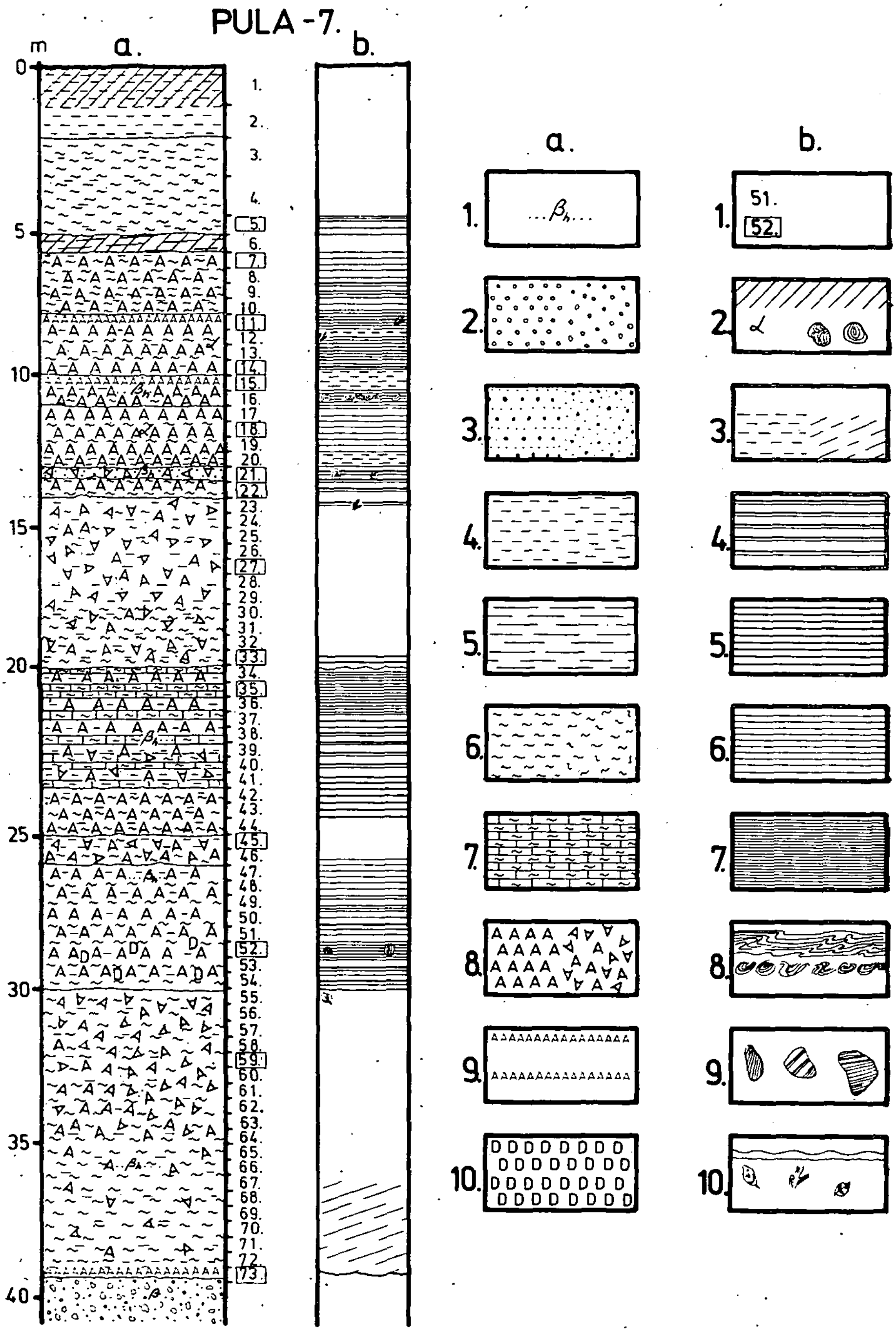

Fig. 3.

member (30.0—39.3 m) but are not predominant. At the boundaries of the lamina pairs the rock favours the parting, these boundaries may be gradual, resp. sharp. All the three lamellar types occur *(Fig. 2.)*. The laminae of carbonate mud are predominating, their quantity gradually decreases upwards though the diatom-bearing and clayey laminae are rather frequent. The formation is nearly horizontal, parallel; between 28.5 and 29.0 m it is convolute within a smaller section. In the lower part of the section the lamina pairs formed series, the thickness of which amounts to several cm.

Sporadically it contains basalt fragments, coalified plant fragments and a few ostracode shells. In the parting surfaces the plant fragments are more frequent. The remnants of the Botryococcus colonies are frequent according to stratification, resp. less frequent indicating the fact that lived only in certain period of the year.

The carbonate content increases resp. decreases according to the lamina members, this may relate to the rhythm of material supply. The porosity of the rock is changing, its bulk density proves to be low.

24.5—26.0 m. Carbonate-muddy oil shale (alginite). It is of "massive" type. It is of light greenish-grey colour, horizontal parting can be rarely observed; rather angular-granular parting is characteristic. In the greater pieces desoriented micro-fissuredness was observed. Both the upper and the lower boundaries are gradual. The rock is homogeneous, the distribution of carbonate content is uniform. On the basis of the textural pictures the organic matter occurs in spots but without orientation and in uniform distribution within the interval (Plate II., photos 1 and 2.).

19.6—24.5 m. Alginite with changing carbonate mud content. It is built up by the alteration of thin "stratified" and somewhat thicker "massive" sections. Lamina members of light greenish-grey, yellowish-grey, green-overshadowed brownish-yellow, greenish-grey and off-white colour were found. The whitish colour indicates the diatom-shells, the yellowish ones the carbonate mud, the darker ones either the accumulation of the organic matter, or the increase of quantity of clay minerals.

The section is inhomogeneous, the lower boundary is gradual and up to about 21.5 m it contains alginite of "massive" type as thin intercalation (which is homogeneous itself). The upper part is of thin-lamellar formation. The thickness of the

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Fig. 3. Sequence *(a)* and stratification *(b)* of the bore Put—7.

Legend:

a) Sequence: 1. rocks containing basalt sand intercalations. 2. conglomerate resp. gravel-bearing rocks. The ordered signs (left side) concern the stratified, the randomly shown marks denote the unstratified formations (in the following it is to be understood in the same sense). 3. sands and sandstones of different grain size (mostly between 0.06 and 0.2 mm). 4. aleurite and aleuritic rocks (mostly between 0.002 and 0.06 mm). 5. rocks containing clay and clay intercalations. 6. rocks of marl and considerable carbonate quantity. 7. carbonate mud; where the dolomite quantity proved to be high, the base-mark of dolomite was used. 8. oil shale (=alginite and alginitic rocks), the randomly placed signs "A" relate to the "massive" type resp. to kindred formation. 9. sections containing alginite of thin-stratified type. 10. diatomite intercalation.

b) stratification and other signs: 1. number of samples, those investigated in detail are in frame. 2. humic ricks with limonite spots and lime concretions. 3. the clear sections are untsratified ("massive" type). The sections of broken line are stratified along the indistinct boundaries. Horizontal lines denote the horizontal and nearly horizontal, oblique lines denote the oblique bedding. 4. series-forming lamina-paired formation. 5. lamina-pairs of cm thickness of order of magnitude. 6. laminapairs of mm thickness of order of magnitude. 7. lamina pairs thinner than mm. 8. lamina-pairs of folded or otherwise dieturbed bedding. 10. hiatus or discordance. 11. coalified plant fragments, stem resp. leaf impressions.

lamina pairs, resp. of the intercalations of "massive" type ranges from tenth mm up to several centimetres. These form occasionally series. In the lower section the boundaries are indistinct, often separation cannot be observed, while in the upper part the boundaries are rather sharp. In the upper part the changes in colour are more expressed. Separation independent of direction and of vertical type occur, clayey or other phenomena relating to displacement could not be observed at these surfaces. The structure of the lamina pairs is homogeneous and may be both gradated or paired.

Between 21.5 and 22.0 m basalt tuff grains of rounded shape and 3 mm diameter were found in the parting surfaces (Plate II., photo 3).

The grain size of the rock is changing, regarding the whole section from down to upwards decrease of grain size can be tendentiously observed.

Bedding is nearly horizontal, on the basis of the core samples neither wedging nor thickening can be determined, the lamina pairs are parallel with one another. Sporadically small coalified plant fragments, occasionally a few ostracod half-shell are found, between 21.5 and 22.0 m shell fragments also occur.

The upper part is characterized by the annual periodicity, the lower one produces rhythmic sedimentation based on different reasons. The change in carbonate content may also be related to this fact. The porosity is high, the bulk density is low, but both of them obviously changes depending on the material quality.

13.4—19.6 m. Alginite (oil shale). It is of "massive" type. Its colour is greenish-shaded light yellowish brown. Certain gradualness can be observed both towards the bottom and the overlying strata. The sample between 16.0 and 16.5 m is most characteristic of the "massive" type, this section contains Botryococcus spots in great numbers. By 1 to 5 cm the air-dried samples become of horizontal parting by hits though no change in material quality can be osberved at the parting surfaces.

The lower sample of the section (19.0—19.6 m) is of transitional type, from the series of lamina pairs of several cm thickness it contains intercalations, while the "massive" part contains smaller clastic sedimentary grains, in addition to the small quantity of carbonates. The upper samples develop gradually from those underlying them (13.4—15.0 m), after slides (Plate IV., photos 1—2) slight orientation can be fixed. Most dissimilar is the sample between 13.4 and 14.0 m which consists of the alternation of the "massive" type and of the lamellar thin-stratified type. The material of the thin-stratified intercalations is mostly carbonate mud, but the quantities of aleurite and clay fractions are also significant.

In general, it can be stated that the "massive" type is of coarser, while the thin-stratified one of finer grain size. This is not valid of the carbonates, these are nearly without exception of very fine, sub-micron grain size. From the middle part of the section the quantity of carbonates shows considerable increase (14.5—17.5 m) both up and downwards.

Bedding is nearly horizontal. The whole part contains only a few coalified plant fragments but it is to be noted that at the parting surfaces of the stratified intercalations of the upper part greater impressions also occur.

13.0—13.4 m. Aleuritic clay marl and sandy aleurite. It is loose and easily friable. Its colour is light yellowish-green. It contacts the overlying strata with a clay-layer of 2 mm, and the underlying one with a layer consisting of coarse grained sand containing rounded basalt grains of 0.5 to 2.0 mm diameter. In the middle of the sample there is also a fine sand layer of 4 mm thickness and of basalt-detritus.

Part of the material to be investigated is indistinctly, the other part well stratified. The thickness of the laminae changes between mm and cm order of magnitude. Within the thicker ones gradation can be observed. In several cases the well thin-stratified laminae are dark-brown and of clayey material. At the parting surfaces corresponding to stratification the coalified plant fragments are frequent (Plate IV., photo 4). Bedding is nearly horizontal.

According to the varied laminae the carbonate is rather different, the rhythmicity in material supply can be imagined.

Porosity changes within wide limits, the bulk density is obviously higher than in case of the previous samples.

Similar mineral composition and textural picture were observed in the section of 11.1—11.6 m of the bore Put—3 (Plate V., photos 1—2).

8.0—13.0 m. Alginitic aleurite, aleuritic alginite and carbonate mud alternate. This is a "thin-stratified type". Light greyish-green, greenish-grey, yellowish-brown, yellowish-greenish-brown, "russet" rusty brown, light creamy-yellow, white-off and white coloured laminae occur.

No petrologically uniform term can be applied which would be valid of a longer section within the given interval. It is built up by lamina pairs of changing material, and the ratios within samples are also different. Studying separately the laminae if it is possible as a function of thickness, their homogeneity can be fixed. The laminae containing Botryococcus colonies, consisting of carbonate mud and being of lamellar type can be distinguished and these occasionally consist mostly of clay minerals. It is to be noted, however, absolutely pure material can be found, neither. Regarding the stage of filling up this is evident. The varied shades of colour indicate also the fact that among the lamina types which seem to be determined, numerous transitions may exist.

In the lower sample and in the samples between 9.0 and 10.5 m there is relatively more clay, while in the samples between 10 and 11, resp. 8.0 and 8.5 m the intercalations of alginite laminae of "shoe sole" type predominate. In the lower two metres between the parting surfaces "russet" rusty-brown spots are found. In several parting surfaces basalt tuff detritus, basalt sand lenses can be observed. The thickness of the lamina pairs is mostly of tenth millimetres, the "thin-stratified" intercalations are of "paper" thickness. The carbonate laminae are somewhat thicker, and can be characterized by a thickness of millimetre order of magnitude. Each lamina pairs are of constant thickness, wedging is infrequent.

Bedding is nearly horizontal, in 10.7 m laminae of folded position can be observed. The whole section contains coalified plant fragments, in the strata surfaces greater monocotyledonous plants of desoriented position are rather frequent (Plate V., photo 3).

The quantity of carbonates is changing and rhythmicity of material supply can be rendered possible. The carbonate material is microcrystalline at most (Plate V., photo 4). Porosity is low, the bulk density is changing.

6.0—8.0 m. Carbonate mud. It is of "thin-stratified" type, and of light, slightly greenish shaded creamy yellow and white-off colour; between 6.5 and 7.0 m sections of darker colour also occur. In several places strips more abundant in algal skelets and of darker greenish-yellow colour can be found. In certain parting surfaces dark-brown, occasionally blackish spots can be observed, this is probably limonite coat.

The rock is characterized by the paired laminated structure. The thicker lamina is carbonate mud, the thinner is pelite. The thickness of the lamina pairs is tenth of mm, resp., mm at most. The boundaries of the pairs is sharp in general, and parting is also frequent. Between 7.0 and 8.0 m series and bundles were also observed.

Bedding is nearly horizontal, the thickness of the laminae is constant, except that of series and bundles. In the sample of the upper part a few drying fissure seem to be probable. The rock contains sporadically a few small coalified plant fragments. The carbonate content increases resp. decreases according to the lamina members. The rock is of medium porosity, its bulk density is changing.

4.8—6.0 m. Clay marl, clayey aleurite. It is of "stratified" type. Light brownish-yellow or white-off strips alternate with brownish-grey ones, some of the parting surfaces are of distinct greenish shade.

The rock is built up by lamina pairs of changing thickness of 0.1 to 10.0mm, most of them are of about 0.5 mm thickness. Lamina pairs form series, the relatively thicker laminae are found though in small number always at the bottom of the series.

2.3—4.8 m. Carbonate mud. It is of pale yellowish-green colour. At the top of the layer 3 cm thick, grey, hard, compact, macrofauna-free limestone of total core diameter and of conchoidal fracture can be found.

1.2—2.3 m. Slope loess? It is of brownish-yellow colour and strongly calcareous.

0.0—1:2 m. Aleurite. Unclassified, and of brown clolour, humic and clayey.

From the surficial outcrop of the geysirite cone of the oil shale occurrence several samples were also investigated. The rock is built up nearly solely of carbonates. It is built up by loose, porous banks of about half metre thickness resp. by the random network of these banks. Plant impressions and fragments infrequently occur though sometimes certain porous parts remind to moss colonies. In one side of the hardly approachable cone the freshwater limestone contains great number of freshwater snails in a thin strip:

Valvata piscinalis O. F. MÜLLER (rare)
Valvata sp. (rare)
Stagnicola palustris O. F. MÜLLER (rare)
Planorbis planorbis L. (frequent)
Planorbis spirorbis L. (less frequent)
Planorbis sp. (in great number)
Gyraulus sp. (rare)
Succinea sp. (less frequent)

PREPARATION OF THE SAMPLES FOR MINERALOGICAL-PETROLOGICAL AND X-RAY DIFFRACTOMETRIC INVESTIGATIONS

Because of the considerable quantity of the soluble and insoluble organic matter content the usual slides could not be prepared from this material. If this phenomenon would not exist as a restraining factor, the colloidal grain size would cause troubles and only a few mineral grains were found which could be assigned to the sandy or aleuritic fractions.

Because of these difficulties we tried to determine the mineral composition of each core samples by means of X-ray diffractometric investigations. In the first step the clayey fraction taken in suspension tried to be deposited, but the solution proved to be turbid also during a longer time and finally only a material of very small quantity deposited in the X-ry diffractogram of which no evaluable peaks were found. Having extracted the soluble organic matter and then having suspended in solution the remaining material with $CaCl_2$, then after staying having centrifuged the sample, in the diffractograms of the sample of accumulated inorganic matter evaluable peaks could be hardly found. It proved to be the most applicable method to pulverize the material vithout any preliminary treatment and this was recorded by X-ray diffractometer. Thus, under the conditions of 500/40 imp/sec peaks suitable for evaluation and relative intensity of measurable size were obtained.

In the course of evaluation of the diffractograms the base line displacement was observed in several cases. This has been in connection with the organic matter content, in general. In case of 5 per cent organic matter (C_{org}) between 15 and 25 Θ angles the base line was of normal run, in case of higher organic matter content it was considerably displaced. The displacement was especially obvious in the bore's samples of 16 to 17 m, as well as in those deriving from the depth of 23 m. Between the two extreme values and depending on the organic matter content all the transitions could be observed *(Fig. 4)*.

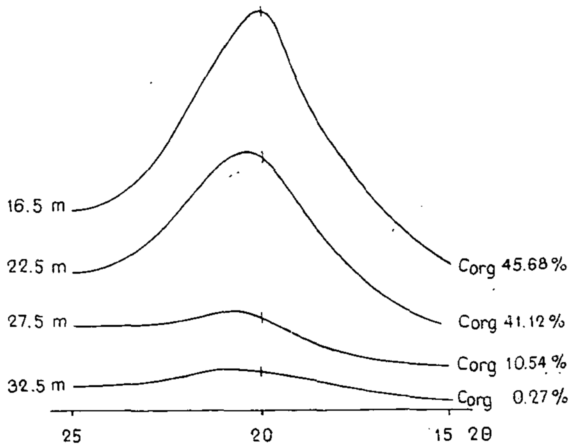

Fig. 4. Base-line displacement depending on the organic matter content.

Another feature of these diffractograms should be mentioned. On the basis of the relative intensities when trying to calculate quantitative relations applying the constants applied and tested till now, no results were obtained. In all cases considerable displacement was observed in case of carbonates in positive direction, which could be controlled on the basis of CO_2 content determined gasometrically. Sometimes in case of slight quantity of CO_2 carbonate mineral of considerable quantity could be computed. In these cases the conclusion has been drawn that the usually X-ray amorphous colloidal material does not contain carbonate but it is rather hydrosilicagel and on this basis it was possible to conclude to the fact that on the one hand clay minerals (montmorillonite, less illite) were also present in most of the investigated samples, and the amorphous material (Table 1) represented considerable quantities, on the other. It is to be assumed that these played a considerable role in the displacement of quantitative relations.

In case of some samples the quantity of the amorphous material has been analyzed by I. VARSÁNYI–TÓTH. Applying the method of J. HASHIMOTO. and M. L. JACKSON, [1960] the quantitative relations of the amorphous SiO_2 and $Al(OH)_3$ of these samples showed the following picture (Table 1):

TABLE 1

Data concerning the quantity of the amorphous material

Depth in metres	C_{org}	CO_2	Amorphous material
	in per cent		
6.5	1.69	17.3	6.00
10.5	11.68	8.2	9.44
16.5	45.68	4.3	5.55
19.0	8.89	21.4	6.88
22.5	41.12	6.9	5.55
25.0	30.09	11.8	7.66
28.5	8.52	17.0	17.44
32.0	10.59	21.5	10.33

According to these data in the change of the amorphous material no relation can be found either with the quantitative changes of CO_2, or of C_{org}, or with that of silicate minerals occurring in higher amounts.

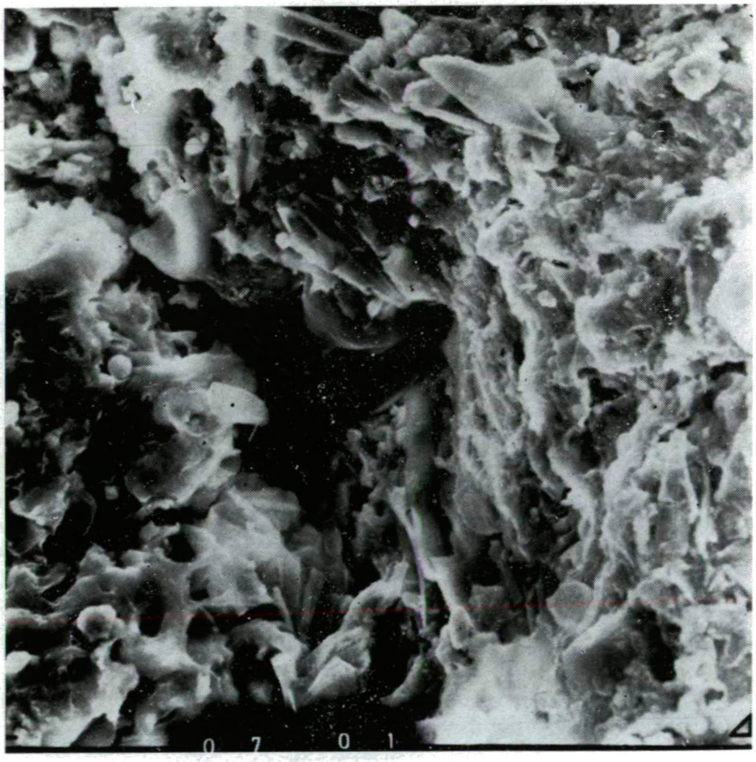

Fig. 5. Oil shale. Surface picture. SEM 1000 X. Record by K. PINTYE—HÓDI. Bore Put—7: 16.0—16.5 m.

The electronmicroscopic picture relates also to the presence of amorphous material of higher amount. In scanning records parts relating to crystalline form could not be identified, only forms characteristic of absolutely irregular, amorphous material could be observe *(Fig. 5)*. In cases where dissimilar textural picture was obtained, the diatom skelet and the coating material of amorphous form could be well distingusihed *(Fig. 6)*.

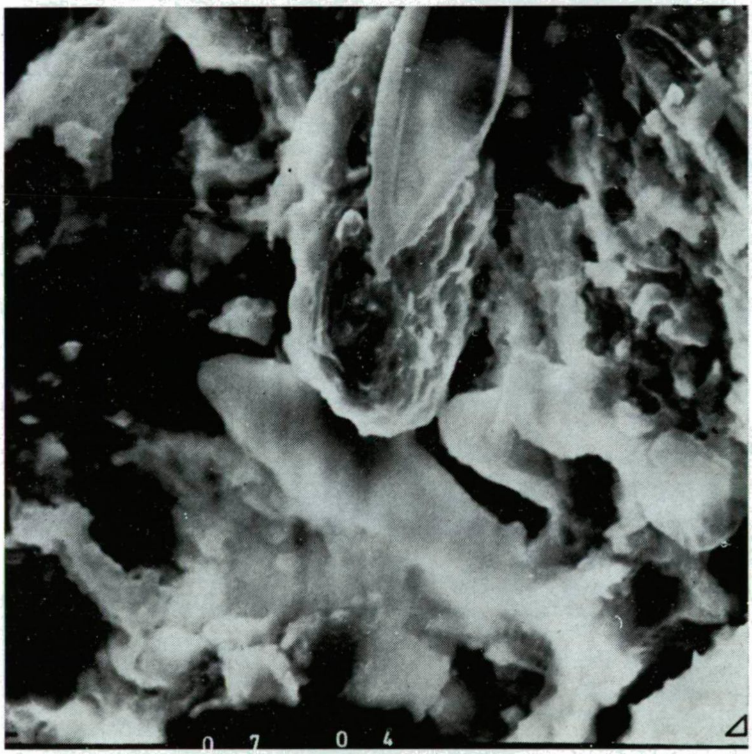

Fig. 6. Oil shale. Surface picture with diatome skelets. SEM 3000 X. Record by K. Pintye—Hódi. Bore Put—7: 16.0—16.5 m.

RESULTS OF THE X-RAY DIFFRACTOMETRIC INVESTIGATIONS

As against to the investigations performed till now it was stated that in the strata sequence of the bore Put—7 the presence of aragonite is common. Investigating its quantitative changes the fact was observed that from the investigated depth of 20 metres down to 40 metres aragonite is of predominant role among the carbonate minerals. Though calcite and dolomite nearly always occur in these samples, the intensity ratios of their most intense peaks are fifth-tenth of those of aragonite. The formation is alginitic marl, but within the interval of 30 to 40 metres it can be considered marl since the carbonate quantity computed from the CO_2 data amounts to about 50 per cent. Between 21.5 and 22 m in the parting surface rounded basalt tuff and basalt grains of 3 mm size can be found which indicate the boundary of the subrhythm.

At about 20 m, i. e. at the bottom of the subsequent subrhythm sandy marl intercalation occurs. Here aragonite gradually disappears and is replaced mostly by calcite, resp. dolomite. From this level towards the higher horizons "massive" alginite occurs, the carbonate content considerably decreases which is also indicated by the lower value of CO_2. In addition to the high porosity, conspicuously small bulk density developed. The change in the mineral spectrum can be followed also in the X-ray diffractogram (Table 2).

TABLE 2

X-ray diffractometric data of the samples deriving from aragonitic and aragonite-free sections

28.5 m			17.5 m		
d_{hkl}	I_{rel}	Phase	d_{hkl}	I_{rel}	Phase
14.022	10	Mont	14.022	9	Mont
9.821	9	I			
6.531	6	Fp			
4.527	7	I			
4.404	10	Mont	4.504	5	Mont
4.228	12	Q	4.290	5	Q
3.840	7	Cal	3.848	6	Cal
			3.736	6	S
3.720	6	Fp			
			3.393	61	A
3.344	47	Q, I	3.344	10	Q
			3.217	27	A
3.241	11	Fp			
3.201	11	Fp			
3.026	35	Cal	3.026	21	Cal
2.883	25	Dol	2.889	10	Dol
			2.701	30	A, Py
2.491	5	Cal	2.487	28	A, Cal
2.435	6	Q			
			2.401	10	A
			2.373	20	A
			2.341	18	A
2.270	11	Q, Cal	2.278	7	Cal
2.190	7	Dol	2.188	8	A, Dol
2.130	5	Q			
			2.107	13	A
2.088	6	Cal			
2.022	4	Dol			
1.980	4	Q			
			1.978	47	A
1.913	12	Cal			
			1.880	31	A
1.871	10	Cal			
1.817	6	Q			
			1.815	18	A

Abbraviations: A — aragonite; Cal — calcite; Dol — dolomite; Mont — montmorillonite; I — illite; Q — quartz; Fp — feldspar; Py — pyrite.

From about 14.5 m the carbonate content rapidly increases and change follow also in the quality of the carbonate minerals, *i. e.* calcite and dolomite become subordinate and aragonite plays the predominant role. In the directly overlying stratum, however, aleurite occurs with decreasing carbonate content and carbonate minerals will be represented by calcite and dolomite again. At the boundary a sandy intercalation consisting of basalt grains occurs which modifies also the mineral spectrum (see Table 3).

TABLE 3

X-ray diffractometric data of the samples deriving from the middle aragonitic and aragonite-free sections

13.5 m			13.0 m		
d_{hkl}	I_{rel}	Phase	d_{hkl}	I_{rel}	Phase
14.484	9	Mont	14.365	12	Chl
			10.377	10	I
			9.931	30	Mu
			8.226	8	Amph
			7.077	20	Chl
5.094	10	Mont			
			4.980	12	Mu
			4.404	6	I
4.426	8	Mont			
			4.247	16	Q
			4.038	8	Fp
			3.744	8	Fp, Mu
			3.532	6	Chl
			3.484	8	Mu
3.384	40	A			
3.344	10	Q	3.344	165	Q, Mu, I
3.265	20	A			
3.196	10	Fp	3.207	50	Fp
3.026	17	Cal	3.026	42	Cal
			2.939	17	Fp
2.883	19	Dol	2.883	37	Dol
			2.784	22	Oliv
2.701	20	A	2.654	11	Dol
			2.566	15	Mu, Chl
			2.541	21	Chl, Dol, Ilm
2.484	23	A, Cal	2.487	20	Cal
			2.454	10	Q
2.401	11	A, Dol			
2.367	13	A			
			2.355	7	Oliv
2.337	17	A			
			2.286	14	Q, Cal
			2.231	10	Q, Oliv
2.190	10	Dol			
			2.121	20	Q
2.102	9	A			
			2.093	11	Cal
			1.990	18	Chl, Mu

Abbreviations: A — aragonite; Cal — calcite; Dol — dolomite; Q — quartz; Mont — montmorillonite; I — illite; Mu — muscovite; Fp — feldspar; Amph — amphibole; Chl — chlorite; Oliv — olivine; Ilm — ilmenite.

In the strata sequence built up by lamina pairs the carbonate minerals are represented only by calcite and dolomite in the interval between about 12 and 8 m, aragonite is absolutely absent. In the overlying carbonate mud calcite and aragonite occur again, here the dolomite is absent (Table 4).

The role of quartz and feldspar is subordinate especially in the carbonate-rich strata, moreover, it can be stated that the decrease of carbonate content is accompanied by the increase of the quartz and frequently of the feldspar quantity. Accordingly, these play a rather subordinate role between the lower 20 to 40 m interval.

TABLE 4

X-ray diffractometric data of the samples deriving from the upper aragonitic and aragonite-free sections

11.5 m			9.5 m		
d_{hkl}	I_{rel}	Phase	d_{hkl}	I_{rel}	Phase
14.721	10	Mont	14.135	12	Mont
5.770	5	Fp			
5.022	5	Mont			
4.470	6	Mont	4.459	10	Mont
4.279	9	Q	4.228	8	Q
4.038	5	Fp	4.020	7	Fp
3.840	5	Cal			
			3.720	10	Fp
			3.624	10	Fp
3.393	45	A			
			3.344	65	Q
3.265	18	A			
3.201	15	Fp	3.162	13	Fp
3.026	37	Cal	3.016	26	Cal
2.889	27	Dol	2.883	18	Dol
2.728	12	A			
2.697	23	A, Py	2.697	12	Py
2.650	3	Dol			
			2.576	6	Mont
2.480	29	A, Cal			
			2.445	7	Q
2.401	12	A, Dol	2.407	5	Dol
2.367	14	A			
2.337	10	A			
2.275	7	Cal			
2.220	8				
2.190	10	A, Dol			
2.107	10	A			
2.097	8	Cal	2.087	6	Cal
1.976	38	A	1.974	12	Q
1.936	4	Cal			
1.902	5	Cal			
1.876	21	A, Cal			
1.815	17	A	1.812	9	Q
1.802	5	Dol	1.804	7	Dol

Abbreviations: A — aragonite; Cal — calcite; Dol — dolomite; Mont — montmorillonite; Q — quartz; Fp — feldspar; Py — pyrite.

The occurrence of clay minerals is common. First of all montmorillonite with or without illite should be taken into account. The lack of montmorillonite was restricted only to a few samples, first of all the material of the lower horizons (downwards from 36 m) contained only illite.

Minerals characteristic of the basalt were found only in few samples. These occurred mainly in the formation which contained coarser-grained material. Olivine, augite and serpentine could be determined. The presence of ilmenite and that of pyrite in the lower horizons proved to be nearly common.

The predominant minerals of the samples of the investigated bore which are characteristic of the formation are as follows: calcite, dolomite, aragonite, quartz, feldspar. The intensity ratios of them were computed so that the reflexion of the diffractogram showing the highest intensity was taken to be 100 and the other intensities were compared to this *(Fig. 7)*. It could be stated that in the formation of the lower horizon aragonite bears predominating role, quartz is sometimes absent and

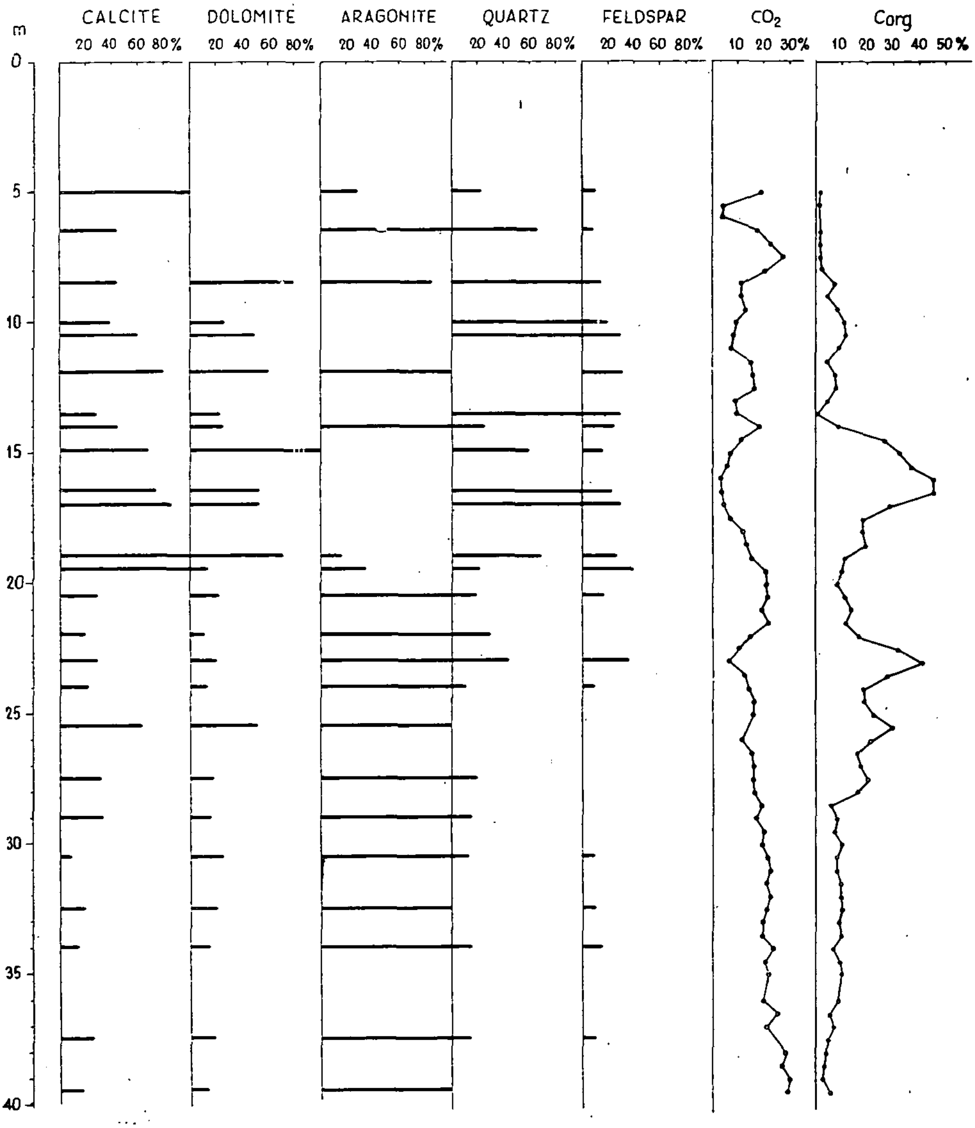

Fig. 7. Change of characteristic minerals as a function of depth.

feldspar is also subordinate. From the point of view of the mineral composition this sequence can be accepted as a uniform series (between 40 and 20 m) during sedimentation no significant displacement or change can be observed.

Between about 20 and 5 m three smaller sections can be distinguished where aragonite is absent and among the carbonates calcite and/or dolomite is of primary importance. In such cases the total carbonate content is lower, in general. At the same time, the quartz content increases, sometimes together with the feldspar content and these form the main minerals of the sequence.

When comparing the quantity of the total organic carbon (C_{org}) and CO_2 content with the mineral spectrum above as a function of depth, the fact can only be stated that in case of decreasing carbonate content the quantity of the organic matter increases, but no correlation was found between the carbonate species, or occasionally with the quartz and feldspar content.

STABILITY POSSIBILITIES AND FORMATION CONDITIONS OF ARAGONITE

It is the first case in the course of investigating the Pannonian sediments that aragonite was found, thus it is worthy to deal with its formation and stability conditions in detail.

F. G. STEHLI and J. HOWER [1961] demonstrated that in shallow hot water the precipitated carbonates show well-defined composition by means of biochemical and physicochemical processes, and aragonite predominates. In addition to it calcite of high Mg-content may also play an important role. In the abyssal carbonate sediments aragonite plays insignificant role beside the calcite of high Mg-content, i. e. the carbonates formed in abyssal waters are more stable. The range of stability of the $CaCO_3$ minerals was determined under normal conditions, and this is as follows: calcite of low Mg-content < aragonite < calcite of high Mg-content. Consequently, only the calcite of low Mg-content is stable as a function of time.

It has been also demonstrated that in recent carbonates aragonite frequently develops in greater amounts, but it is also known that in Pleistocene carbonates aragonite does not occur. Consequently, aragonite is instable in the sedimentary range and remain during longer times in metastable state when it does not contact aqueous solutions.

It is obvious from the facts mentioned above that in the surface and near-surface regions aragonite is instable under normal pressure and temperature conditions. Transformation takes place by means of solutions. Aragonite may remain, however, during geological times where it was bedded into clayey rocks, oil shale or asphalt of low permeability [in: H. FÜCHTBAUER, G. MÜLLER, 1970; A. HALAM, M. J. O'HARA, 1962]. Except the conditions above, aragonite is metastable in the sedimentary and diagenetic ranges.

Taking the presence of aragonite in the bore of Pula (Put—7) it is obvious that in spite of its instable structure aragonite may be preserved if the enclosing rock is clayey and less permeable or if it is an oil shale. No explanation is given, however, on the formation of aragonite since in this case the shallow sea cannot be taken into account, but only smaller or greater lake system being sometimes independent of one another may be in question.

In the environs of the Pula bores Á. JÁMBOR and G. SOLTI [1975] determined a lagoon enclosed by the ring-shaped tuff barriers of the volcanic crater which was mostly separated from the sediment-transporting flows of the surrounding oligohaline lake. As a result of the relative depth of the lake, of the independence of wind and of the covering of the water table by algal colonies the fine-lamellar structure resulted in by slow sedimentation might be preserved. Though microflora and pollen analyses evidence a warm climate, the temperature of the lake would not be high enough to make possible the precipitation of $CaCO_3$ as aragonite.

It is to be assumed, therefore, that after the completion of the volcanic activity the hot-spring activity began within a relatively short time which is proved also by the presence of geysirs and in the chemical composition of hot-springs $Ca(HCO_3)_2$ played an important role. This would be an explanation to the higher carbonate content and predominating character of aragonite in the lower part of the sequence in the Pula bore.

The hot-spring remnants occurring in the recent surface are of different consistency. Part of them is compact with minimal porosity, the other part is loose and strongly porous. The occasionally intercalated banks are of abundant snail fauna. On the basis of X-ray diffractometric investigations the part of the sequence containing snail fauna consist nearly solely of calcite in addition to the minimal quartz content, the other types, on the other hand, consist of dolomite independently of the porosity and contains only rarely small amount of calcite or feldspar. The quartz and feldspar derive probably from the Pannonian sediments (Table 5).

TABLE 5

X-ray diffractometric data of the geysirite samples

Material of geysirites (surficial outcrop)								
loose			compact			„snail-bank"		
d_{hkl}	I_{rel}	Phase	d_{hkl}	I_{rel}	Phase	d_{hkl}	I_{rel}	Phase
4.030	10	Dol	4.038	8	Dol			
						3.848	23	Cal
3.706	20	Dol	3.698	20	Dol			
			3.344	6	Q	3.344	4	Q
3.207	4	Fp						
3.026	4	Cal				3.026	260	Cal
2.883	275	Dol	2.883	275	Dol			
						2.839	7	Cal
2.678	12	Dol	2.673	12	Dol			
2.541	10	Dol	2.541	12	Dol			
						2.460	27	Cal
2.403	40	Dol	2.407	32	Dol			
						2.280	40	Cal
2.194	90	Dol	2.192	78	Dol			
						2.093	40	Cal
2.068	13	Dol	2.066	7	Dol			
						1.910	40	Cal
						1.872	40	Cal
1.850	14	Dol	1.850	10	Dol			
1.807	30	Dol	1.807	35	Dol			
1.790	50	Dol	1.788	48	Dol			
						1.624	7	Cal
						1.602	17	Cal
1.568	8	Dol	1.568	8	Dol			
1.545	20	Dol	1.545	17	Dol			
						1.522	9	Cal

Abbreviations: Dol — dolomite; Fp — feldspar; Cal — calcite; Q — quartz

The periodical appearance of aragonite and the change of the mineral composition within the bore can be explained by the fact that this lake of relatively warm water heated by the waters of hot-springs was inundated from outside by a colder water of higher salt concentration from time to time, thus the decrease of temperature and the change of salinity were enough to stop the precipitation of aragonite. Simultaneously, the grain size of the sediment is changing, quartz becomes usually predominating and feldspar plays also more important role. In these cases the quantity of the total carbonate decreases since the lake's water was diluted and its temperature also decreased. The original equilibrium, however, returns within a short time and this allows the conclusion that the incoming colder water quantity of other salt concentration was less significant. In the bore three inundation periods can be distinguished which can be followed also in the change of textural features of the core material. By means of this the sudden change in the mineral composition can be explained.

In relation with the organic matter's quantity slight connection with the mineral composition can be demonstrat d, since in the sections where aragonite is absent and the mineral composition changes the percentual quantity of C_{org} will be usually high, which can be caused by the large-scale growth and death of the algal colonies just because of the changed biotope. The greater abundance of the organic matter in certain horizons and in greater depths cannot be sufficiently explained yet.

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EXPLANATION OF PLATES

PLATE I, Bore Put—7.

1. 39.0—39.3 m. Textural picture of alginitic carbonate mud. In the lighter strips the slight accumulation of carbonates can be observed. Ostracods. // N, M = 35 x.

2. 36.0—36.5 m. Alginitic carbonate mud, unstratified ("massive") type. The traces of Botryococcus colonies and spots of organic matter show random occurrence. // N, M = 140 x.

3\. 32.0—32.5 m. Alginitic marl, unstratified, though the arrangement of Botryococcus colonies suggests some kind of orientation, the spot-like accumulation of the carbonate content, however, interrupts these "series". Slide is perpendicular of bedding. // N, M = 35 x.

4. 32.0—32.5 m. Section of the previous slide. // N. M = 140 x.

PLATE II, Bore Put—7.

1. 25.0—25.5 m. Oil shale (alginite), unstratified type. The record is a part of a carbonate mud spot in which indistinct Botryococcus colonies and spots consisting of organic matter are shown. // N, M = 35 x.

2. 25.0—255. m. Oil shale (alginite). Section consisting mostly of Botryococcus colonies. // N, M = = 140 x.

3. 21.5—22.0 m. Basalt sand grain from the thinstratified alginite — carbonate mud section of lamina-paired structure. Slide is parallel with bedding. // N, M = 140 x.

PLATE III, Bore Put—7.

1. 20.0—20.5 m. Coalified plant tissue fragment on the surface of lamina of carbonate mud material. Slide is parallel with stratification. // N, M = 140 x.

2. 16.0—16.5 m Alginite. Textural picture of unstratified ("massive") type with a lot of Botryococcus colonies. // N, M = 10 x.

3. 16.0—16.5 m. Section from the previous slide. // N, M = 35 x.

PLATE IV, Bore Put—7 .

1. 14.5—15.0 m. Alginite. Slightly oriented texture, transition between the "massive" and "startified" types, it is inclined to part by shocks, no change in material quality can be observed at the surfaces. Slide is perpendiof the parting surface. // N, M = 10 x.

2. 14.5—15.0 m. Section of the previous slide. // N, M = 140 x.

3. 13.4—14.0 m. Coalified plant fragments on the surface of carbonate mud lamina. N, M = 140 x.

4. 13.0—13.4 m. Textural picture of the lamina of basalt tuff matter. The same section is abundant in clay minerals, as well. // N, M = 10 x.

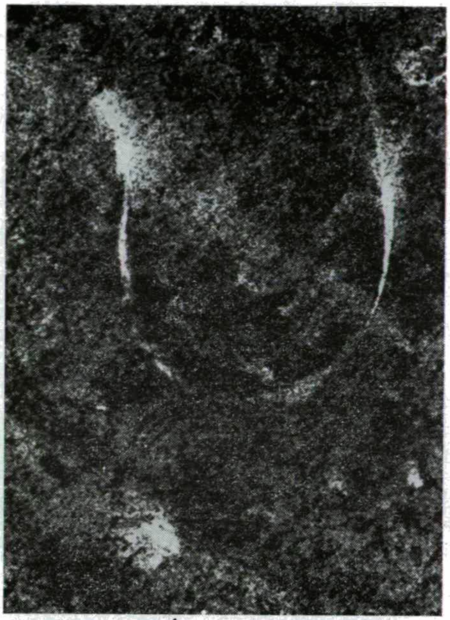
PLATE V

1. Bore Put—3. 11.1—11.6 m. Grain fragments cemented by carbonate mud and of mixed origin From lamina of basalt tuff matter. // N, M = 140 x.

2. Bore Put—3. 11.1—11.6 m. The same but crossed. // N, M = 140 x.

3. Bore Put—7. 9.0—9.5 m. Plant fragment on the surface of a lamina of mostly carbonate mud material. // N, M = 140 x.

4\. Bore Put—7. 8.0—8.5 m. Textural picture of carbonate mud. // N, M = 140 x.



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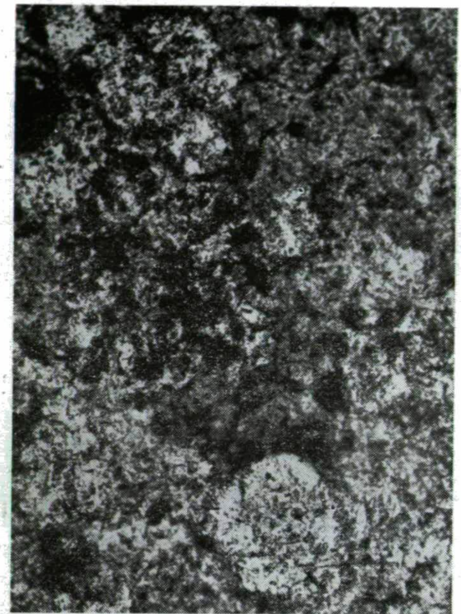

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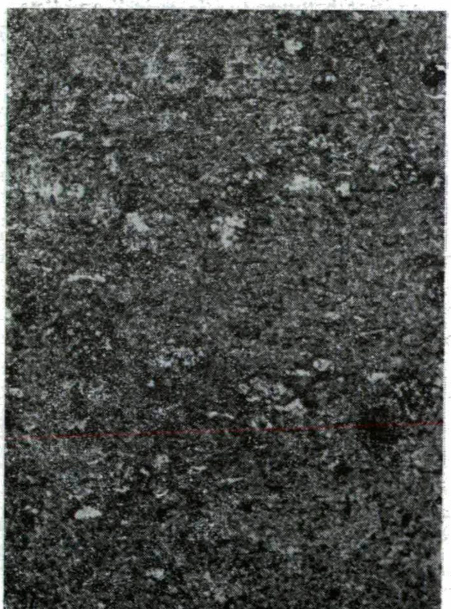

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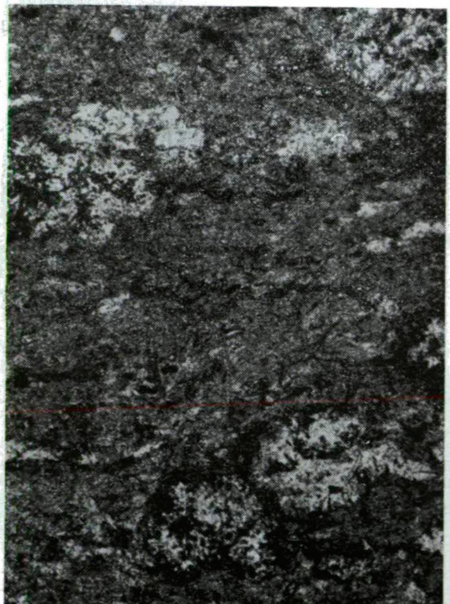

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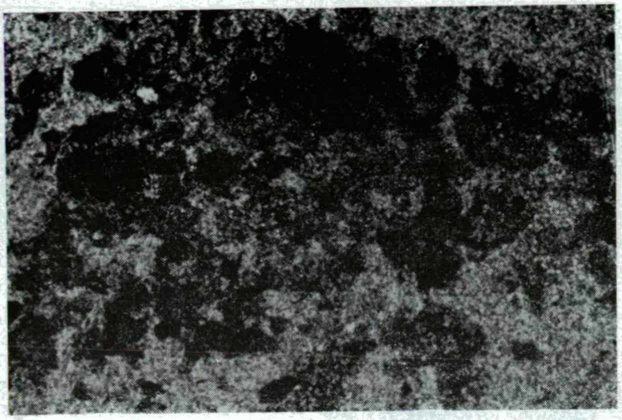

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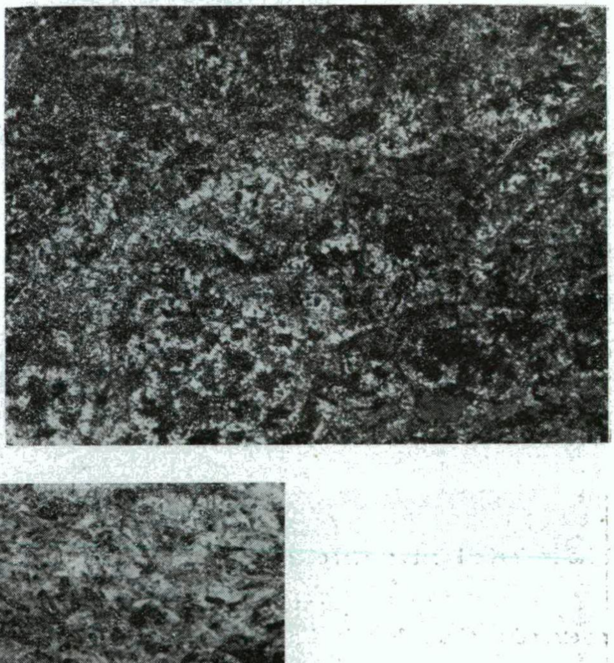

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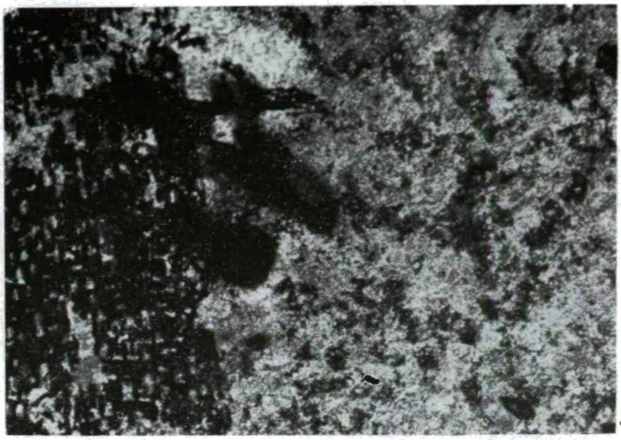

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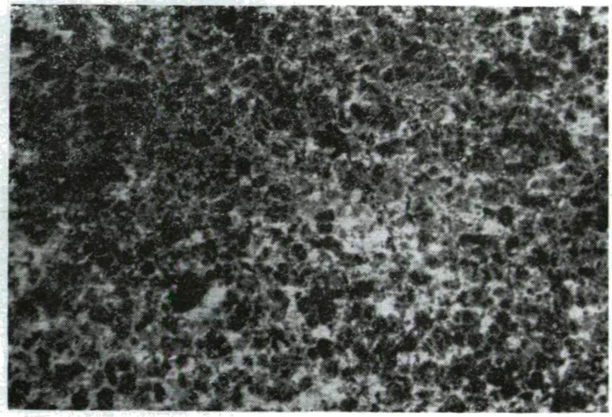

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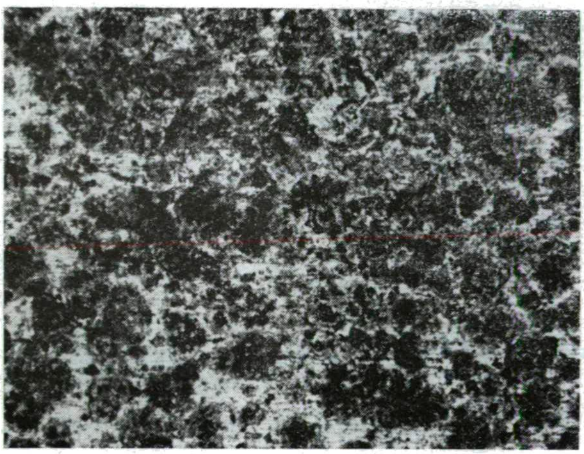

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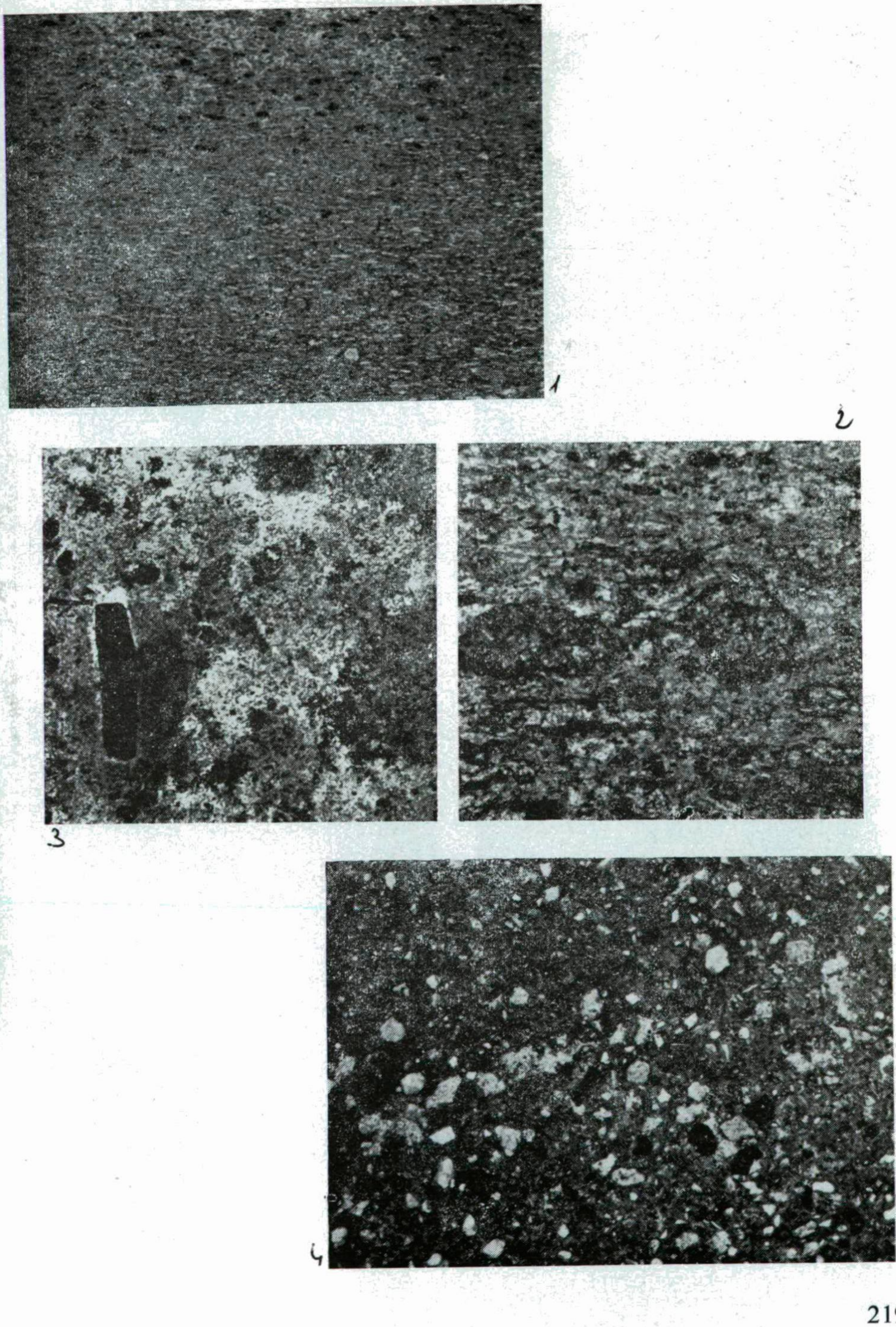
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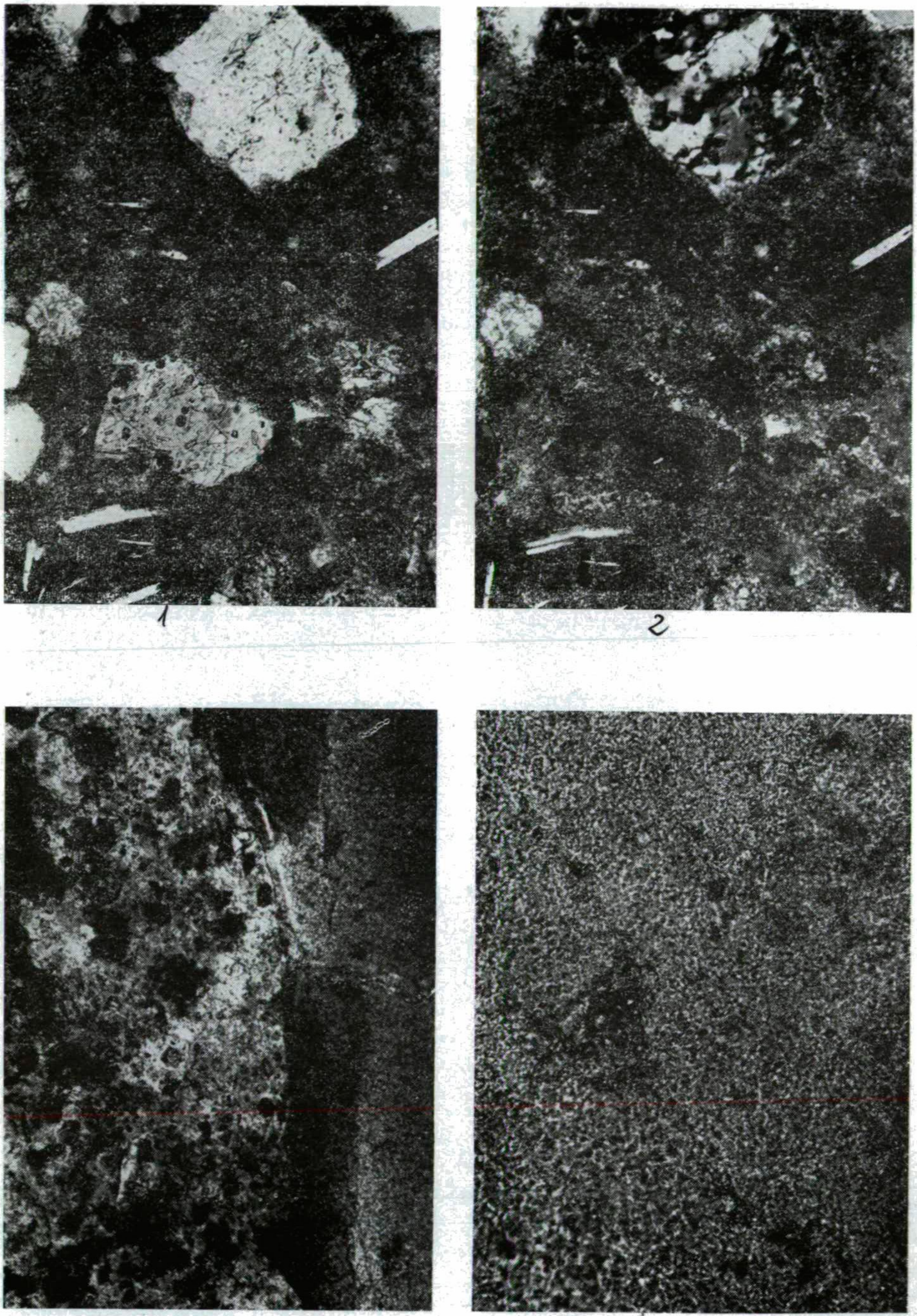

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SEDIMENT VOLUME OF THE HUNGARIAN OIL SHALES IN ORGANIC SOLVENTS

I. VARSÁNYI and M. LISZKAI

INTRODUCTION

Sediment volume of the Hungarian oil shales from Pula (Balaton Highland area) was determined in organic solvents of different polarity.

The purpose of the work was to find a quick and simple method to choose samples coming to detailed examinations.

Therefore, connections were looked for between the sediment volume and the amount of organic and inorganic components of the oil shales.

The structure and the volume of the sediments formed from suspensions are determined by the type of the dispersed material, the dispersing medium, the size, the shape and the surface quality of the dispersed particles, as well as by the temperature.

OSTWALD and HALLER [cited by SZÁNTÓ *et al.* 1971] studying the sediment volume of powders in organic solvents found that the sediment volume decreases with increasing dielectric constant of dispersing medium. The sediment volume is influenced by the wetting power of the medium by BLOM and it is influenced by the adhesive power between the particles by BUZÁGH [see SZÁNTÓ *et al.*, 1971]. The higher the adhesion the looser the structure of the sediment, consequently, the sediment volume becomes higher.

Adhesion is determined by the character of the adsorption layer, i. e. in water and in solutions of electrolytic conductors by the change and depth of the adsorption layer and in non-electrolyte by the structure and depth of the lyosphere, respectively. So, the sediment volume of hydrophylic powder is fairly high in apolar liquids because of the thin lyosphere and strong adhesion but it is small in polar liquids because of the thick lyosphere and weak adhesion.

Mixing a polar solvent into the system the sediment volume of polar powders decreases monotonously in apolar liquids. According to OSTWALD and HALLER [see SZÁNTÓ *et al.*, 1971] this fact can be explained by the oriented adsorption of the polar molecules.

The sediment volume in organic solvents is strongly influenced by the presence of water even in small amount.

The conditions in swelling systems capable of peptization are different from those of compact-grained systems.

In swelling systems the number of the particles is important regarding to the sediment volume, so the sediment volume is increased by the peptization and disaggregation.

The adsorption of organic material changes the surface conditions and therefore it influences strongly the sediment volume.

MATERIALS

Samples were collected from the borehole Put—7 from 38,5 to 4,8 m depth. Mineral components determined by X-ray diffractometry by Mezősi (personal communication) are calcite, dolomite, aragonite, quartz, feldspar, clay minerals, olivine and pyrite.

The organic material content of the samples is fairly high. Organic material consists of soluble and insoluble organic components.

The short description of the geological section by Mucsi (personal communication) see in Table 1.

Table 1

Short description of the samples

Depth (m)	Number of the sample	Characterization of the samples
39,3—30,0	73—55	Lime-marl rich in alginite with coalified plant remnants.
30,0—26,0	54—47	Alginite with high content of lime-marl, clayey laminae and coalified plant remnants. The porosity of the sample is various.
26,0—24,5	46—44	Alginite with lime-marl.
24,5—19,6	43—34	Alginite with lime-marl. The amount of the organic material is increased.
19,6—13,4	33—22	Aleurolite with significant clay content. The porosity of the sample is high.
13,4—13,0	21	Aleurolitic fine sandstone.
13,0— 8,0	20—11	Alginitic aleurolite, aleurolitic alginite and lime-marl with coalified plant remnants.
8,0— 6,0	10— 7	Lime-marl with coalified plant remnants.
6,0— 5,4	6	Clay marl, clayey aleurolite with few plant remnants.
5,4— 4,8	5	Lime-marl, clayey aleurolite.

EXPERIMENTAL PART

The samples were air-dried, they were ground in ball mill and sieved. The grain size used is under 0,1 mm. Experiments were carried out in test-tube of 20 ml. 0,8 g material was suspended in 10 ml solvent. Sediment volume was measured about one week later when it did not show any changes.

The soluble organic material was extracted by chloroform to obtain bitumen-A (Bit-A) then by the mixture of benzene-acetone-methanol to obtain BAM bitumen-A (BAM Bit-A).

The carbonate contents were measured by gas volumetric method and the organic carbon contents by burning.

Four solvents of different dielectric constant were chosen to determine the sediment volume:

	dipole moment	dielectric constant
benzene	0	2,2
chloroform	1,15	5,1
methanol	1,69	33,7
nitrobenzene	4,00	36,4

Sample	Depth (m)	Metha ml
5	4,8— 5,4	1,5
6	5,4— 6,0	1,4
7	6,0— 6,5	1,6
8	6,5— 7,0	1,8
9	7,0— 7,5	1,6
11	8,0— 8,5	2,0
14	9,5—10,0	1,9
15	10,0—10,5	2,0
17	11,0—11,5	1,9
18	11,5—12,0	2,0
20	12,5—13,0	1,8
21	13,0—13,4	1,2
22	13,4—14,0	1,8
24	14,5—15,0	2,3
25	15,0—15,5	2,3
26	15,5—16,0	2,7
27	16,0—16,5	2,4
29	17,0—17,5	2,1
30	17,5—18,0	2,1
31	18,0—18,5	2,1
33	19,0—19,6	1,8
34	19,6—20,0	2,4
35	20,0—20,5	2,2
38	21,5—22,0	2,3
39	22,0—22,5	2,5
40	22,5—23,0	2,2
42	23,5—24,0	2,5
43	24,0—24,5	2,4
45	25,0—25,5	2,3
47	26,0—26,5	2,1
48	26,5—27,0	2,3
52	28,5—29,0	2,8
58	31,5—32,0	2,5
59	32,0—32,5	2,3
62	33,5—34,0	2,4
66	35,5—36,0	2,7
67	36,0—36,5	2,6
69	37,0—37,5	2,4
71	38,5—39,0	2,0
72	39,0—39,3	2,0

+ volume of the material gath

Table 2 contains the depth of the samples, the values of sediment volumes, the carbonate and total organic carbon contents.

Sediment volumes in the more polar methanol are lower than in the less polar chloroform, in benzene and nitrobenzene they are between those of methanol and chloroform.

It can be supposed that there is an adsorption layer on the surface of the particles and this absorption layer consisting of organic material is fairly polar. This is support-

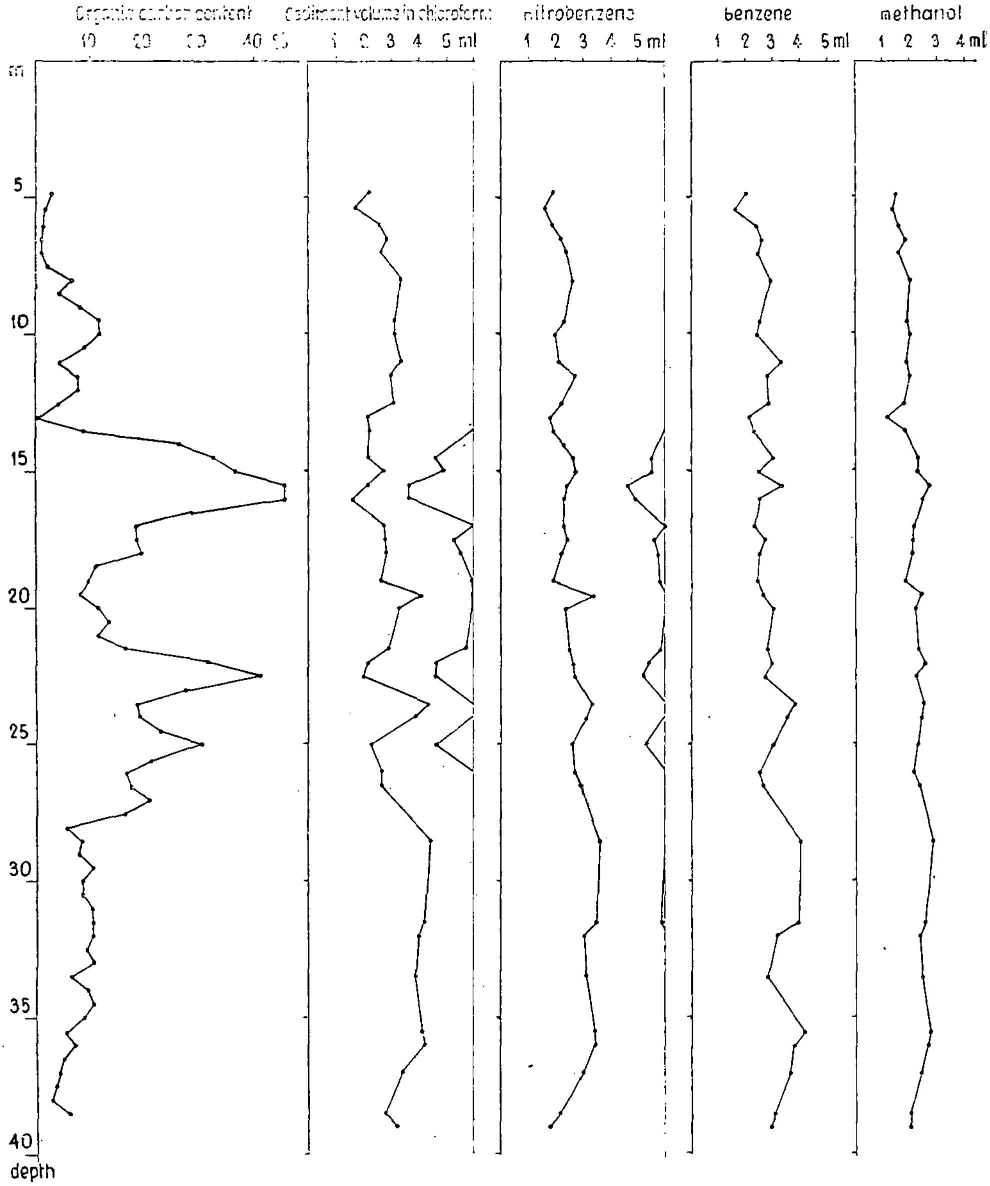

Fig. 1. Organic carbon content and sediment volume as a function of depth.

ed by the fact that the particles are flocculated and settled like floccules in the apolar benzene and chloroform.

The sediment volume and organic carbon contents as a function of depth are shown in *Fig. 1.*

Particles of several samples were separated into two phases, an upper and a lower one. As it can be seen on *Fig. 1* samples of very high organic carbon contents are separated. Organic carbon content was measured in upper and lower phases of sample No 27. Organic carbon content of the upper phase is 65,6 per cent and that of the lower phase is 19,3 per cent. So, this separation can be attributed to the difference of specific gravity between organic and inorganic components of the samples.

Of course separation took place only in chloroform (specific gravity 1,5) and nitrobenzene (sp. gr. 1,2) but it did not occur in benzene (sp. gr. 0,9) and methanol (sp. gr. 0,8). Maximum amount of the upper phase of the separated samples coincides with the maximum of the organic carbon contents.

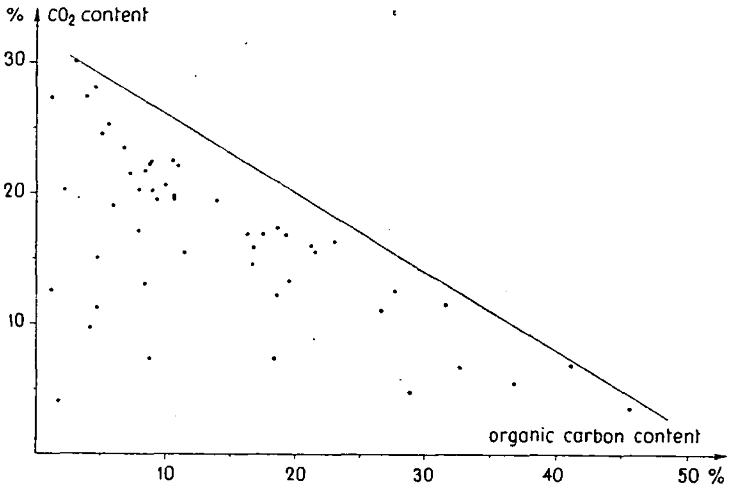

Fig. 2. Connection between CO_2 and organic carbon content.

A direct connection between the depth and the sediment volume could not be established because factors influencing the sediment volume are altered in a different way with the depth.

Considering the sediment volume depending on the carbon dioxide they do not show any connections.

The CO_2 and organic carbon contents are shown by *Fig. 2.* As it can be seen CO_2 contents decreases with increasing organic carbon contents, but in several samples these two factors seem to be independent of each other because of other minerals present in the samples.

To study the organic carbon contents and the sediment volume the amount of the organic carbon was recalculated into 100 g of the inorganic mineral components *(Figs. 3* and *4).*

In each solvent the sediment volume changes according to a maximum curve. The maximum is at about 10 per cent organic carbon contents. Reaching the maximum the curve declines but over 25 per cent organic carbon contents the sediment volume becomes independent of the quantity of the organic carbon.

Effect of the soluble organic material on the sediment volume was also studied. Bit-A and BAM Bit-A are shown in Table 3 [GRASSELLY *et al.*, 1975].

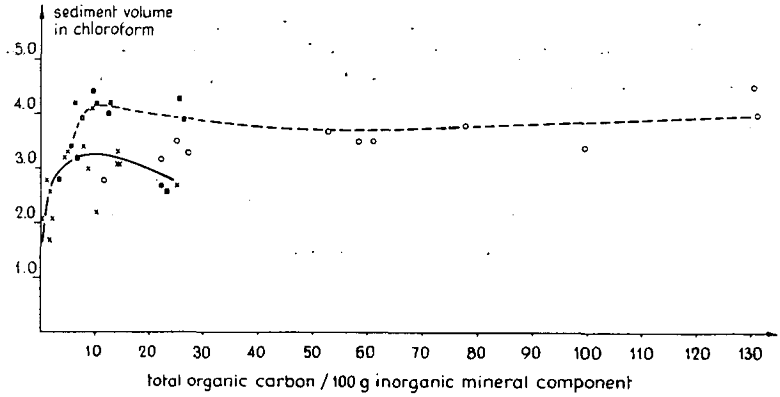

Fig. 3. Sediment volume in chloroform depending on total organic carbon content.
■ Samples from 39,0 to 20,0 m depth.
× Samples from 20,0 to 4,8 m depth.
○ Samplex with high organic carbon content from 39,0 to 20,0 m depth.

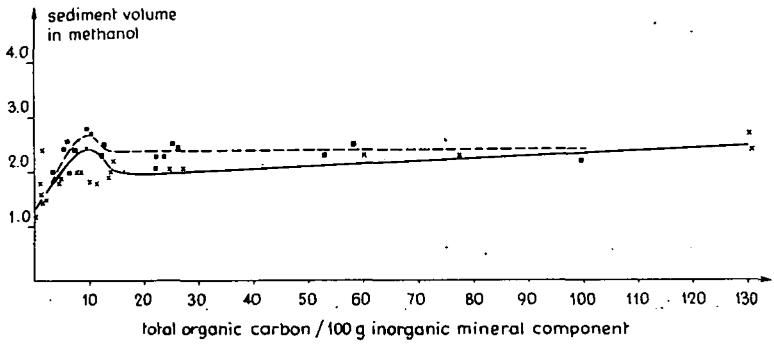

Fig. 4. Sediment volume in methanol depending on the total organic carbon content.
■ Samples from 39,0 to 20,0 m depth.
× Samples from 20,0 to 4,8 m depth.

The sediment volumes determined in benzene and in chloroform depending on the amount of the soluble organic material are shown by *Figs. 5* and *6*.

These curves show also a maximum similarly to *Figs. 3* and *4*. In this case maximum is at about 1 per cent of soluble organic material. This fact suggests that the sediment volume is influenced rather by the soluble organic material than by the insoluble one.

Samples were extracted by chloroform and by the mixture of benzene-acetone-methanol then dried at 60 °C. Sediment volume of these samples were determined in chloroform, benzene and methanol (Table 4).

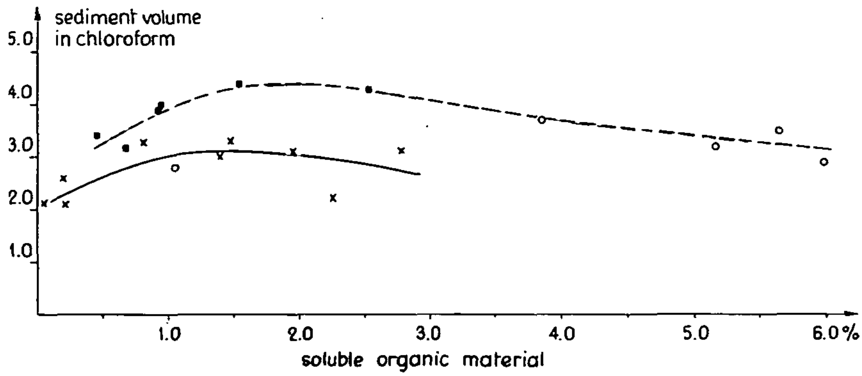

Fig. 5. Sediment volume in chloroform depending on the soluble organic material.
■ Samples from 39,0 to 20,0 m depth.
× Samples from 20,0 to 4,8 m depth.
○ Samples with high organic carbon content from 39,0 to 20,0 m depth.

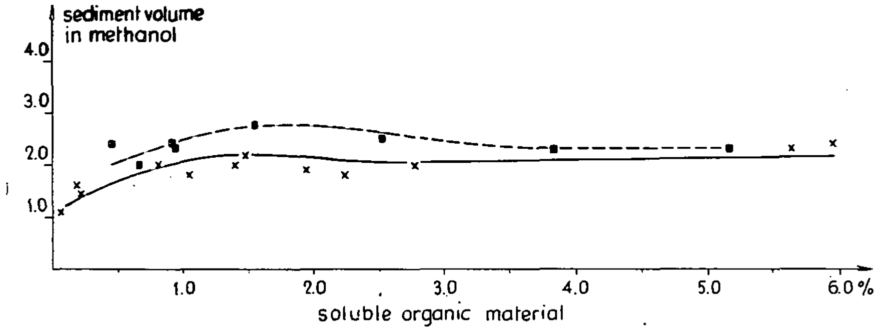

Fig. 6. Sediment volume in methanol depending on the soluble organic material.
■ Samples from 39,0 to 20,0 m depth.
× Samples from 20,0 to 4,8 m depth.

In methanol and chloroform values show a saturation curve and in benzene they give a maximum, but this maximum is not so intensive as the values obtained before extraction *(Figs. 7.* and *8).*

The sediment volume obtained after extraction are lower than before extraction but the types of the curves are similar in both cases. It may be assumed that soluble organic material is adsorbed on the surface of inorganic mineral components. In all probability the sediment volume is influenced by adsorbed soluble organic material. Since the shape of the curves is similar before and after extraction this adsorption may be considered partly a chemical and partly a physical one.

The organic material bound by physical adsorption can be extracted by organic solvents, but the organic material bound by chemical adsorption remains on the surface even after extraction. This chemically adsorbed layer results the similar shape of the curves before and after extraction.

On the basis of *Figs. 3* and *5* it can be seen that samples can be grouped into three types. One of the types contains organic material in a fairly great amount. This type separates into two phases in chloroform and nitrobenzene. Sediment volume of the

TABLE 3

Bit-A, BAM Bit-A and total soluble organic material contents of the samples

Sample No	Bit-A %	BAM Bit-A %	Total soluble organic material %
5	0,14	0,07	0,21
7	0,11	0,08	0,19
11	0,61	0,19	0,80
14	1,40	0,54	1,94
15	2,34	0,43	2,77
18	0,84	0,55	1,39
21	0,05	0,01	0,06
22	1,80	0,43	2,23
24	3,61	2,04	5,65
26	5,12	1,73	6,85
27	3,95	2,01	5,96
33	0,55	0,49	1,04
35	1,15	0,32	1,47
38	3,99	1,18	5,17
42	1,56	0,95	2,51
45	2,99	0,85	3,84
52	1,06	0,48	1,54
59	0,67	0,27	0,94
62	0,53	0,38	0,91
69	0,28	0,17	0,45
72	0,43	0,23	0,66

TABLE 4

Sediment volume and insoluble organic carbon contents of the samples after extraction

Sample N⁰	Sediment volume in Methanol (ml)	Benzene (ml)	Chloroform Lower phase	Upper phase	Insoluble organic carbon/100 g mineral component
5	1,4	1,7	1,9		2,17
7	1,5	2,0	2,0		1,35
11	1,8	2,2	2,2		6,98
14	1,8	2,0	2,3		11,47
15	1,8	2,0	2,1		11,18
18	1,7	1,9	1,9		7,34
21	1,2	1,7	1,7		0,17
22	1,7	1,7	1,7		8,11
24	2,4	2,3	1,5	1,6	48,30
27	2,5	2,8	1,0	2,5	101,00
32	2,0	1,9	1,9	0,3	11,58
33	1,4	1,8	1,8	0,3	10,50
35	1,7	2,2	2,4	0,4	12,63
38	2,2	2,6	1,4	1,7	15,90
42	2,5	2,4	2,2	0,7	22,99
45	2,2	2,4	1,5	1,4	44,62
52	2,1	2,6	2,9		7,20
59	1,9	2,4	2,9		11,45
72	1,9	2,4	2,4		6,15

samples belonging to the second type gives a maximum curve, the value of the sediment volume is fairly high. The curve of the third type is under the curve of the second type.

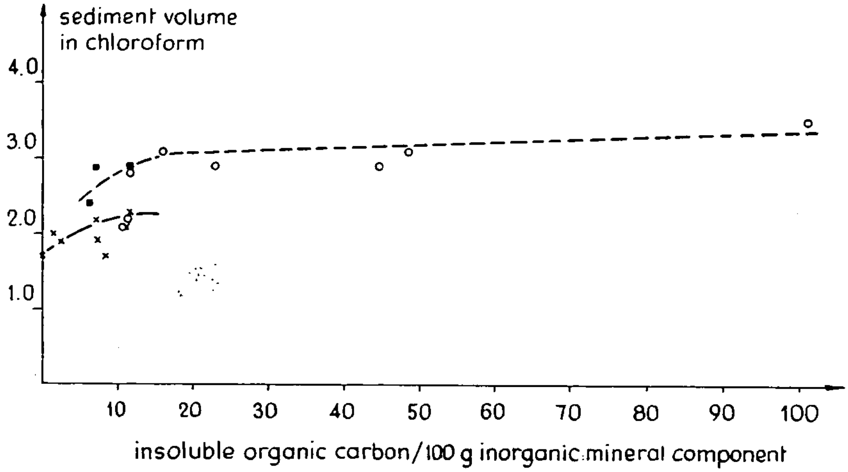

Fig. 7. Sediment volume of the extracted samples in chloroform.
■ Samples from 39,0 to 20,0 m depth.
× Samples from 20,0 to 4,8 m depth.
○ Samples with high organic carbon content from 39,0 to 20,0 m depth.

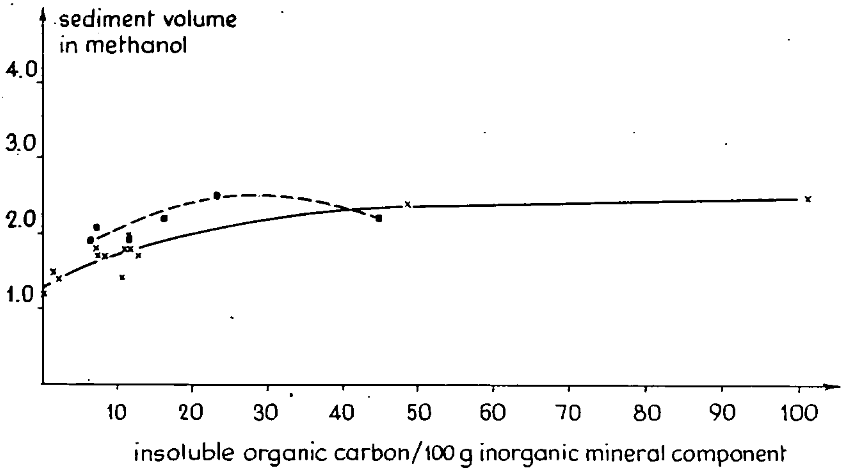

Fig. 8. Sediment volume of the extracted samples in methanol.
■ Samples from 39,0 to 20,0 m depth.
× Samples from 20,0 to 4,8 m depth.

According to MEZŐSI (personal communication) within the Püt—7 borehole two cycles can be distinguished, samples below 20,0 m depth contain more carbonate, aragonite prevails among the carbonates, the quantity of the quartz and the feldspar is negligible. Above 20,0 m depth the quantity of the quartz and the feldspar is more significant and the carbonate contents of the samples decreases.

The two types represented by the two curves mentioned above coincide with the samples belonging to the two sedimentation cycles.

Samples with high organic material contents belonging to the third type can be inserted into both sedimentation cycles.

SUMMARY

Sediment volume of Hungarian oil shales was measured in organic solvents and it was compared with the organic carbon and soluble organic material contents. The accumulation of the organic material in oil shales can be detected by measuring sediment volume in organic solvents of 1,2 to 1,5 specific gravity. The organic material concentrates in an upper solid phase on the top of the solvent due to its low specific gravity.

Considering connections between the total and soluble organic material as well as the sediment volumes it was supposed that the sediment volume is influenced rather by the soluble organic material. One part of this „soluble" organic material can be removed indeed by extraction, however, "soluble" organic material adsorbed by chemical force remains on the surface. In this case "soluble" organic material means chemical type and not the amount of organic material which is really extracted.

The sediment volume is influenced by the mineral components, too. Samples with higher carbonate and lower quartz contents have higher sediment volume than samples with lower carbonate and higher quartz contents. The samples from 39,0 to 20,0 m depth represent the type of low quartz and high carbonate contents with aragonite and the samples from 20,0 to 5,0 m depth contain quartz and feldspar, small carbonate without aragonite.

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CONTRIBUTIONS TO THE ISOLATION OF THE KEROGEN IN HUNGARIAN OIL SHALES

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ABSTRACT

Concentration of kerogen of the Hungarian alginites can be carried out by separation in organic solvents. This method is very quick, it does not need a lot of work and the solvent can be removed without residue. Applying other physical method, e. g. separation in calcium chloride solution the amount of the kerogen concentrate is larger but its organic carbon content smaller than using chloroform for separation. The quality of the organic phase is better if solvents of lower specific gravity are used. As the other physical separation methods, this one has also the disadvantage that the kerogen of samples of low organic content can not be separated. Acidic treatment of the samples of high carbonate and relatively low organic carbon content promotes the separation by physical method.

INTRODUCTION

The kerogen is in organic solvents insoluble part of the organic material of the sediments. In order to study its structure, first of all it has to be separated from the soluble organic material and mineral components. The soluble part is extracted in different organic solvents (chloroform, acetone, benzene, methanol and/or their mixture). To separate mineral components is much more difficult than to remove soluble organic material. Some sediments are argillaceous, others calcareous and/or contain pyrite or quartz. On removing these minerals it needs various methods.

Requirements for isolation methods [FORSMAN, 1963]:

1. No chemical alteration of the kerogen should take place in the process.
2. The method should yield sufficient pure material for elemental analysis and degradation studies.
3. Fractionation of the kerogen should be avoided, that is the kerogen concentrate obtained should be representative of the starting material.

The methods used for isolating kerogen are physical or chemical ones.

Physical methods

Differential wettability method

This procedure was used first by QUASS [1939, cited by Eglinton and Murphy, 1969], who isolated kerogen of Australian torbanites. Later this technique has been employed and modified by various authors. According to ROBINSON [1969] "method is based upon the principles of differential wetting of the organic kerogen and the inorganic mineral by two immiscible liquids such as oil and water. The organic kerogen is wet by the organic liquid phase and the mineral is wet by the water phase resulting in the kerogen being retained in the oil phase and the mineral being released into the water phase". The advantage of this method is that the isolated kerogen remains chemically unaltered. The disadvantage is that it takes a long time and in numerous cases only a small part of the minerals can be removed.

Flotation method

The flotation method are based upon the differences in the specific gravity of the kerogen and the minerals. The separation is taken place in a liquid of specific gravity which is between that of the kerogen and the minerals. The specific gravity of the mineral components usually changes from 2 to 5.

The specific gravity of Green River Formation kerogen 1,07. FORSMAN and HUNT [1958] also published data on the specific gravity of some kerogens, but these data have been corrected for mineral content, which consists chiefly of pyrite and insoluble fluorides. By them the corrected specific gravity of the Green River kerogen 1,22—1,38.

Aqueous calcium chloride solutions are often used in the flotation techniques. [cited by EGLINTON and MURPHY, 1969].

HUBBARD *et al.* [1952], carried out the separation with a mixtures of carbon tetrachloride and benzene (specific gravity between 1,15—1,40). The kerogen rock were extracted with benzene and carbonates were removed. The material was centrifuged in the mixture of specific gravity — mentioned above — which first was 1,40, second 1,20 and third 1,15. By repeated flotation the yield of the kerogen can be increased only in a small degree, but the ash content will be less than 10 per cent.

Generally the advantage of the flotation technique is that the kerogen does not altered chemically, however, on the other hand, it gives a high ash content. The method can be used only in cases of rocks relatively rich in kerogen.

Chemical method

The chemical method has in general the advantage that the kerogen obtained is purer and has a lower ash content, however, the mineral components can not perfectly be removed.

Its disadvantage is, however, it takes a long time, consists of successive steps, and each step have to be repeated, and the structure and composition of the original kerogen will be attacked by the chemicals used.

At first, the carbonates are decomposed usually by hydrochloric acid. Hydrochloric acid is suitable because such a way the calcium can be removed as well. In the next steps silicates and quartz are removed by hydrogen fluoride, but the presence of the calcium disturbs this treatment, due to formation of insoluble calcium fluoride [FORSMAN and HUNT, 1958]. After removing the fluorides the residue is treated first with ammonium hydroxide, then with hydrochloric acid and hydrogen fluoride, respectively. This process is repeated some times [LÜCK, 1969].

Pyrite can be removed by a reduction with zinc and hydrochloric acid [FORSMAN and HUNT, 1958], or with $LiAlH_4$ used by other authors.

According to HIMUS [1950] "There is no universally satisfactory method for the determination of the composition of kerogens in a kerogen rock, every sample must be the subject of special investigation". DANCY and GIEDROYC [1950] similarly states that "no method generally applicable for removal of mineral matter from oil shales can be described, and variations must be made to suit individual samples". [See BREGER, 1963].

EXPERIMENTAL PART

Examination of the insoluble organic material is necessary for study the genesis of the newly discovered Hungarian oil shales. Therefore organic material of sufficient quantity and of low ash content has to be isolated. Some of the available samples can be separated by physical method but another part having lower organic carbon content can be isolated only by chemical method.

Since the structure of kerogen does not suffer alteration at all during physical technique, it was important to develop a quick and simple physical method to obtain insoluble organic material in sufficient quantity for investigation.

Comparing the physical and the chemical method some differences can be established in the organic materials obtained by these two different ways (Table 1).

TABLE 1

Specific gravity, ash, organic and inorganic carbon content of the kerogen isolated by chemical and physical method

	Kerogen isolated by physical method	Kerogen isolated by chemical method
Specific gravity	1,16	1,04
C_{org} %	66,9	69,2
C_{inorg} %	0,6	0,0
Ash %	7,2	1,2

Although the kerogen isolated by chemical method seems to be purer — lower ash and inorganic carbon content — still this method destroys the structure of the kerogen. It is demonstrated by the infrared spectra of the kerogens *(Fig. 1)*.

As it can be seen on the *Fig. 1,* the spectrum of the kerogen isolated physically has more bands, than that of the kerogen isolated chemically. For example band between 3600—3100 cm^{-1} (νOH band), and some bands in the region between 1800—1000 cm^{-1} are missing in spectrum of kerogen isolated chemically.

The mineral components of the Hungarian oil shales from neighbourhood of Pula detected by X-ray diffractometry, are calcite, dolomite, aragonite, clay minerals, quartz and feldspar, olivine, pyrite (J. MEZŐSI's personal communication). The specific gravity of these minerals is between 2—5.

The specific gravity of kerogen isolated from different oil shales by different methods is between 1,07—1,51 [FORSMAN and HUNT, 1958; BREGER, 1963].

The specific gravity of the kerogen isolated from Hungarian oil shales by chemical method is 1,03—1,05.

On the basis of the differences in the specific gravity the organic and inorganic components can be separated in liquid phases having a specific gravity of 1,1 to 1,9.

Organic solvents appear to be more suitable for separation because they wet these materials perfectly. Aqueous solutions do not wet organic compounds so that the problem of wettability arises.

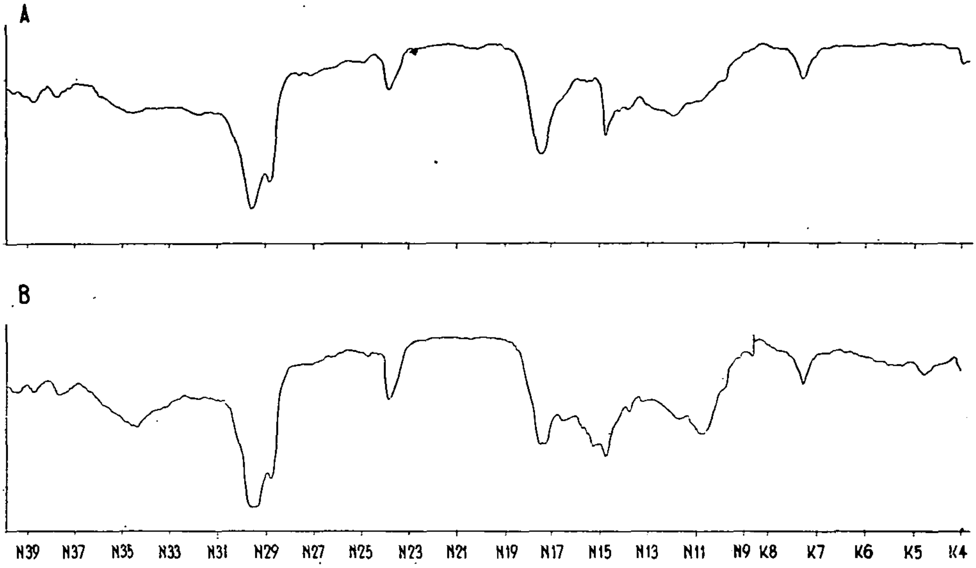

Fig. 1. Infrared spectra of the upper phase of the sample 4.
A = isolated by chemical method
B = isolated by physical method

Considering problems mentioned above chloroform (sp. gr. 1,5) and mixture of chloroform and methanol (sp. gr. 1,15 to 1,35) were used for separation.

Four samples were chosen from Hungarian oil shales (Table 2).

TABLE 2

Depth, organic and inorganic carbon content of the samples

Sample N°	Depth (m)	Original sample C_{inorg} %	Original sample C_{org} %	Sample extracted C_{inorg} %	Sample extracted C_{org} %
1	14,5—15,0	1,8	32,6	2,3	26,3
2	16,0—16,5	1,2	45,7	1,2	40,5
3	19,5—20,0	5,9	9,8	5,9	6,6
4	25,0—25,5	3,2	30,1	3,4	27,0

Three of them have high organic carbon content (>30 per cent) and one has a relatively low organic carbon content (<10 per cent). The inorganic carbon content changes from 1,2 to 5,9 per cent.

The separation was carried out with original samples as well as with samples extracted by chloroform and mixture of benzene-acetone-methanol, respectively.

The air dried core samples were first ground in ball mill (grain size <60 μm), and after extraction the samples were dried at 60 °C.

1,5 g of the sample was suspended in 20 ml solvent in a tube, and when the suspension have been separated into two phases, the upper phase was removed. Both solid phases were dried at 60 °C.

The same samples were also separated in aqueous solution of $CaCl_2$ (sp. gr. 1,20). Flotation was made by MRS BERTALAN on the basis of the method of FOMINA *et al.* The results of the two different methods have been compared, as follows.

Two phases were gained in organic solvents, and three phases in $CaCl_2$ solution.

The quantity, the organic and the inorganic carbon content of each phase and the ash content of upper phase was determined. Results are given in Table 3.

TABLE 3

Values of some parameters of the upper and lower phases separated by different physical method

		Separation in chloroform		Separation in aqueous calcium cloride solution		
		Upper phase	Lower phase	Upper phase	Middle phase	Lower phase
Sample 1						
Quantity	%	34,2	65,8	2,6	18,0	79,4
C_{org}	%	56,7	16,7	65,7	41,9	22,6
C_{inorg}	%	0,6	3,0	0,0	1,4	2,7
Ash	%	18,2		8,6		
Sample 2						
Quantity	%	58,6	41,4	12,1	61,4	26,5
C_{org}	%	59,3	18,6	71,0	48,2	21,7
C_{inorg}	%	0,3	3,5	0,1	0,8	2,0
Ash	%	16,3		8,6		
Sample 3						
Quantity	%	6,0	94,0	1,5	5,2	93,3
C_{org}	%	66,3	5,2	70,9	40,3	11,4
C_{inorg}	%	0,5	7,1	0,2	3,2	6,4
Ash	%	15,1		8,1		
Sample 4						
Quantity	%	31,0	69,0	8,6	32,0	59,4
C_{org}	%	65,5	12,6	70,4	43,2	18,9
C_{inorg}	%	0,7	4,5	0,3	2,4	4,1
Ash	%	14,0		7,4		

As it can be seen on the Table 3, the amount of the organic phases separated in chloroform is larger, than the organic phases gained in $CaCl_2$ solution. The quality of kerogen is characterized by ash and organic carbon contents. Considering these values the quality of the organic phases separated in chloroform is not as good, as the first phase, but better than second organic phases gained by $CaCl_2$ method. However, the lower phase separated in chloroform are more suitable for further mineralogical analysis because of their lower organic matter content. Due to the high organic carbon content the baseline of the X-ray diffractograms displaces, thus, the evaluation of the diffractograms is very difficult. After physical separations, lower phases is suitable to X-raying.

It was supposed that repeated separation of the upper organic phase supplies a concentrate of higher organic carbon and lower ash contents. The separation of the upper phase of the sample 2 was repeated three times. The organic carbon and ash contents are shown in Table 4.

TABLE 4

Ash and organic carbon content of the upper phases of the sample 2 separated by different physical method

		Separation in chloroform	Repeated separation in chloroform	Separation in aqueous $CaCl_2$ solution
C_{org}	%	59,3	71,3	71,0
Ash	%	16,3	8,4	8,6

The organic carbon content is increased, the ash content is decreased, so, their values are the same, as that of the upper phase flotated in $CaCl_2$ solution.

Isolation by means of organic solvents is a very quick method and these solvent are removed by drying at 60 °C. In this way even the repeated separations require less work, than the method using $CaCl_2$ solution.

It was examined whether the removing of carbonates influences the separation. Carbonates were removed by monochlor-acetic acid. These samples were not extracted previously. The results are given in Table 5.

TABLE 5

Quantity, organic and inorganic carbon content in original samples as well as in samples after removing carbonates

		Separation of the original sample		Separation of the sample free of carbonate	
		Upper phase	Lower phase	Upper phase	Lower phase
Sample 1					
Quantity	%	34,2	65,8	42,1	57,9
C_{org}	%	62,2	17,9	61,7	26,5
C_{inorg}	%	0,5	2,8	0,0	0,0
Sample 2					
Quantity	%	55,1	44,9	70,0	30,0
C_{org}	%	65,6	19,3	63,0	29,2
C_{inorg}	%	0,1	2,3	0,0	0,0
Sample 3					
Quantity	%	6,0	94,0	13,8	86,2
C_{org}	%	62,6	7,2	66,1	18,7
C_{inorg}	%	0,5	6,1	0,0	0,0
Sample 4					
Quantity	%	31,9	68,1	55,5	45,0
C_{org}	%	61,5	13,5	59,3	26,8
C_{inorg}	%	0,7	4,3	0,0	0,0

After the acid treatment the amount of upper phases increased, their organic carbon content practically remained the same. Because of the increase of the efficiency of the separation some samples with high carbonate and relatively low organic carbon content become also suitable for physical separation.

Four further samples were examined. The CO_2 content of the samples: 9,5 per cent (sample 5), 8,2 per cent (sample 6), 22,1 per cent (sample 7), 21,5 per cent (sample 8). Their organic carbon content changes between 10,5 and 11,7 per cent. After acidic treatment sample 7 and 8 became separable by physical method, but sample 5 and 6 did not seem suitable for physical separation.

In order to obtain kerogen with higher organic carbon content and lower ash content the samples were separated in the mixture of chloroform and methanol (sp. gr. 1,25). Results are shown in Table 6.

TABLE 6

Values of some parameters of the upper and lower phases separated in organic solvents

		Separation in the mixture of chloroform and methanol		Separation in chloroform	
Specific gravity of the solvents		1,25		1,50	
		Upper phase	Lower phase	Upper phase	Lower phase
Sample 1					
Quantity	%	17,2	82,8	34,2	65,8
C_{org}	%	62,2	21,2	56,7	16,7
C_{inorg}	%	0,4	2,7	0,6	3,0
Ash	%	13,2		18,2	
Sample 2					
Quantity	%	50,0	50,0	58,6	41,4
C_{org}	%	65,3	24,0	59,3	18,6
C_{inorg}	%	0,2	1,8	0,3	3,5
Ash	%	10,9		16,3	
Sample 3					
Quantity	%	3,6	96,4	6,0	94,0
C_{org}	%	66,9	6,0	66,3	5,2
C_{inorg}	%	0,4	6,6	0,5	7,1
Ash	%	6,8		15,4	
Sample 4					
Quantity	%	8,2	91,8	31,0	69,0
C_{org}	%	66,9	24,8	65,5	12,6
C_{inorg}	%	0,6	3,6	0,7	4,5
Ash	%	7,2		14,0	

The amount of the organic phase decreased concerning the efficiency of the separation in chloroform. Organic carbon content increased slightly, but ash content significantly decreased.

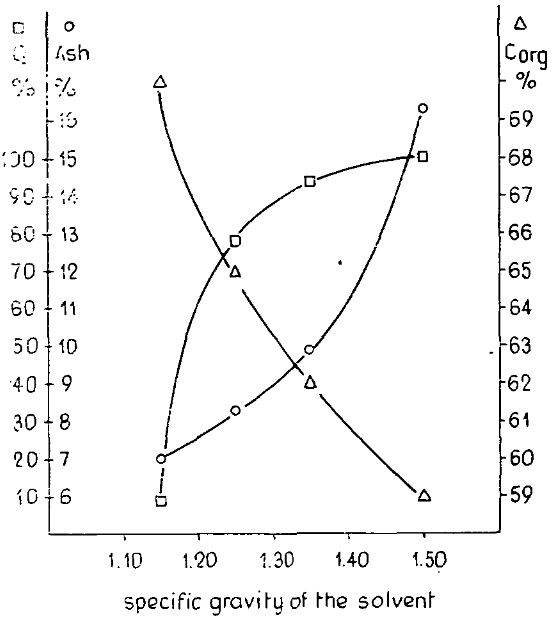

Fig. 2. Quantity, ash and organic carbon content in the function of the specific gravity of the solvent.

On studying the effect of the specific gravity of solvents, the upper phase of the sample 2 was separated in solvents of different specific gravity. (Table 7) Previously 10 g of sample 2 was separated in chloroform. The organic phase obtained in this way was dried at 60 °C. The dried material was suspended in the mixture of chloroform and methanol having specific gravity of 1,35, 1,25 and 1,15, respectively. The amount of the kerogen was decreased, the organic carbon content increased and ash content also decreased by the decreasing specific gravity.

TABLE 7

Values of some parameter in the two phases of samples separated in the mixture of organic solvents having specific gravity

		Specific gravity of the solvents						
		1,50	1,35		1,25		1,15	
		Upper phase	Upper phase	Lower phase	Upper phase	Lower phase	Upper phase	Lower phase
Quantity	%	100	94,1	5,9	77,8	22,2	9,2	90,8
C_{org}	%	59,0	61,8	36,0	65,0	59,7	70,3	65,4
C_{inorg}	%	0,3	0,2		0,1		0,1	
Ash	%	16,3	9,9		8,3		7,0	

SUMMARY

Kerogen of Hungarian oil shales from neighbourhood of Pula was separated by a physical method. Since the specific gravity of the mineral components is greater than 2 and that of the kerogen less than 1,2, the specific gravity of the liquids suitable for separation is between 1,2 and 2. Organic solvent as well as the mixture of organic solvents were used for they wet the samples well. Further advantage of organic solvent is that they can easily be removed from the solid phases.

Removing of aqueous salt solution is difficult, it can be carried out by repeated washing, and it causes loss in the amount of organic material. In a solvent of comparatively high specific gravity, for example in chloroform (sp. gr. 1,50), the first separation gives kerogen with not so good quality, as in aqueous solution. Repeating the separation of the upper phase in the same solvent, the ash and organic carbon contents become as good as that of the kerogen obtained in $CaCl_2$ solution.

Separation in the mixture of solvents (sp. gr. 1,25) results in a higher organic carbon and a lower ash content than in the chloroform alone.

One of the disadvantages of the physical technique is the high ash content. Repeated separation gives better results, the ash content decreases.

The advantage of the separation in solvents is the large amount of the organic phase. For some examinations the quality of the material of relatively high ash content is sufficient, as well. However, some analyses need material of high quality. Therefore, samples can be separated in chloroform to obtain a large quantity of organic material then this material can be purified by solvents of lower specific gravity.

According to our experience, acid treatment promotes the separation of the samples of relatively low organic carbon content. This effect appears in the materials of high carbonate content. It is due to the relativ increase of the organic carbon content after having removed the carbonates.

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A COMPARISON OF THE SEDIMENTARY STRUCTURES OF SOME UPPER-PANNONIAN INTRABASINAL AND MARGINAL SEDIMENTARY SEQUENCES

M. Szónoky

INTRODUCTION

The Pannonian formations represent the largest volume of sedimentary rocks within the geologic record of Hungary. The water- and hydrocarbon resources of these layers have been revealed by a number of exploratory wells drilled in a rather uneven areal distribution. The paleontological stratigraphical hydro- and petroleum-geological characteristics of these formations have been discussed in a number of fairly valuable studies. In spite of this fact there are significant differences from place to place in the level and amount of knowledge concerning these formations. We are still heavily lacking — for instance — some information connected with the characteristics of the intrabasinal and marginal sediments and with the variation of the margines of the Pannonian sedimentary basin. The detailed discussion of these shortcomings is beyond the scope of this study. Although the difficulties in delineating the sediments infilling the Pannonian Basin horizontally and vertically explain a number of things, the reluctance in doing the method of comparing the different facies is considered as one of the sources of the existing shortcomings. This is why the author's intention is to distinct two — one intrabasinal and one marginal — Upper-Pannonian sequences which could be correlated in time and to analyse them as thoroughly as possible by demonstrating the analogies and distinct features in their lithological and litho-faciological development.

The samples of the so called marginal facies were taken in water exploring boreholes with continuous core sampling in Keresztespuszta (boreholes Keresztespuszta—1, 2, 3; abbrev.: Kp—1, 2, 3) and Tortyogó (boreholes Tortyogó—4; abbrev.: To—U/4), all situated south of the Permian-Mesozoic mass of the western part of the Mecsek-Mountain (S.-Hungary). The core samples representing the intrabasinal development were recovered from 26 and 2 hydrocarbon exploring boreholes with a rather scattered core sampling in the Algyő and Szeged area (Southern Part of the Great Hungarian Plain) respectively. These samples have been qualitatively described by the author within the framework a service contract between the Geological and Paleontological Department of the József Attila University of Sciences (Szeged) and the National Oil and Gas Trust of Hungary.

In addition to registering the fabric as well as internal and external forms of the sedimentary structures the comparative studies of the author have based on facies analyses considering macro- and microfossils equally. After drawing the paleo-geographical conclusions from the methods mentioned above stratigraphical details and historico-geological relationships of the areas involved have also been outlined, detailed discussion of which is beyond the scope of our recent study.

The paleogeographical setting of the samples representing the intrabasinal and marginal facies is shown in the *Fig. 1.*

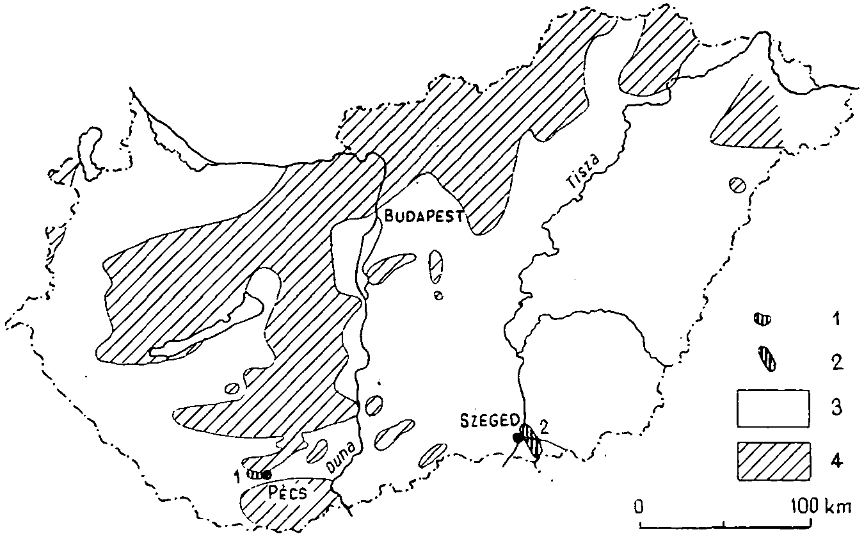

Fig. 1. The paleogeographical setting of the areas Keresztespuszta and Algyő-Szeged at the border of the Lower-Upper-Pannonian. [After Kőrössy, L., 1971]. 1. Area of Keresztespuszta; *2.* Algyő- Szeged area; *3.* open water table; *4.* Islands.

I. THE MARGIN OF THE SEDIMENTARY BASIN: THE GEOLOGICAL SETTING OF THE AREA KERESZTESPUSZTA-TORTYOGÓ (SOUTH-HUNGARY)

A basin with a W—E strike is shown in the "Structural Map of the Pre-Tertiary Basement of Southern-Transdanubia" [1964], in the southern foreground of the western part of the Mecsek Mountain. The basin is bordered by the Permian—Mesozoic anticline of the western part of the Mecsek Mts. from the North, and by the crystalline anticline of the Görcsöny—Gyód area revealed by boreholes only. The area studied here (Keresztespuszta—Tortyogó) is on the northern slope of this basin.

During the Upper-Pannonian the whole mass of the Mecsek Mts. emerged forming a middle-mountain, while the contrasted movement of the depression situated in the southwestern foreground during the Pannonian has developed a depositional basin for the sediments eroded from the mountains. This relatively high rate of subsidence of the area studied decreased to zero by the end of the middle section of the Upper-Pannonian, so that the upper part of the Upper-Pannonian could not be formed here at all. The setting of this "chanell" connecting large basin-units in Transdanubia and in the Great Hungarian Plain may have been a very significant parameter as for the fauna of the area involved *(Fig. 1)*. The well-agitated meso-, myo- and oligohalyn waters flowing from the East may have also created favourable conditions for the evalution of the Pannonian faunal assembladges.

The boreholes studied stopped in Upper-Permian, Upper-Triassic fractured sandstone, slaty siltstone, dolomitic marl, intersected heavily by faults and upthrusts, as a conseuquence of the immediate vicinity of a tectonic zone. The boreholes Kp—1 and 2 have reached the basement in a more elevated structural position, the boreholes

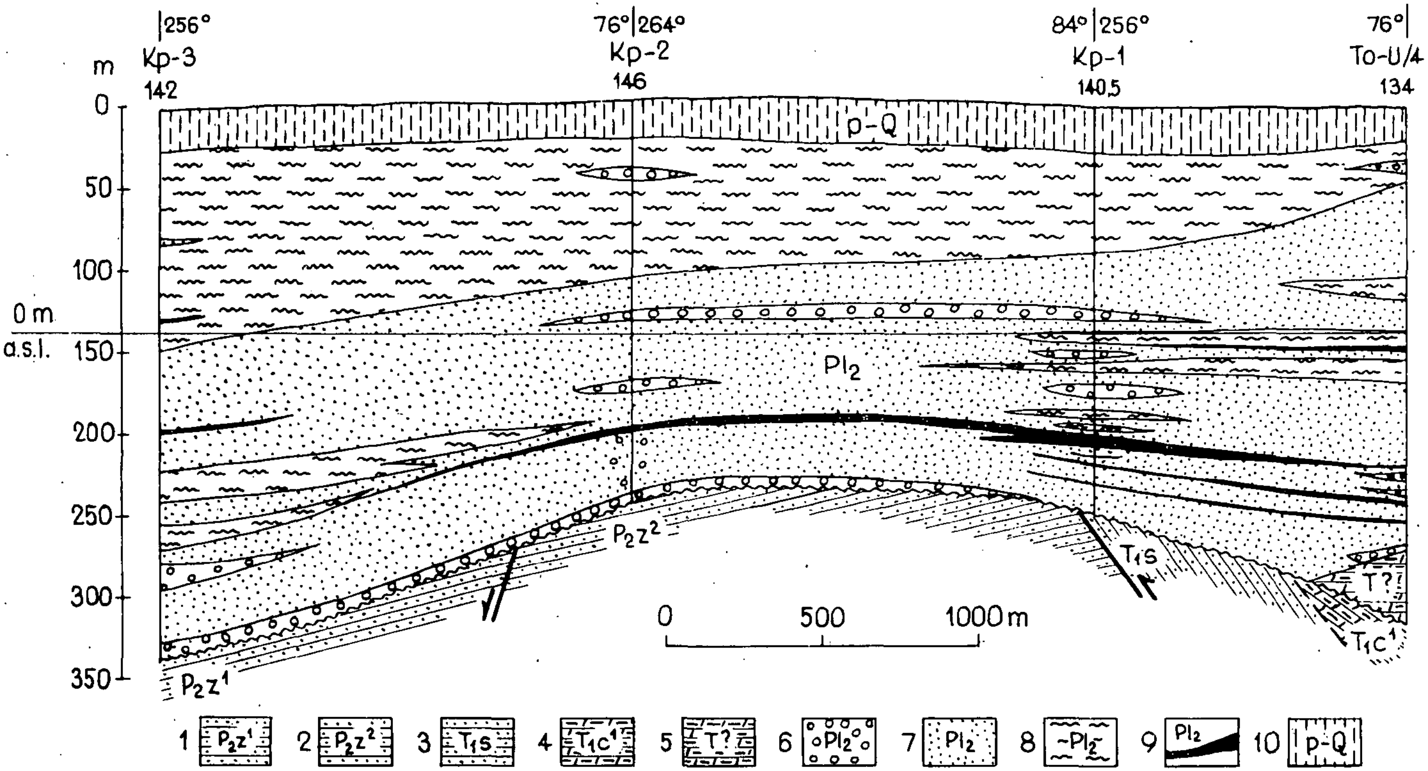

Fig. 2. Geological profile between the boreholes Keresztespuszta—3 and Tortyogó—U/4. *1—2.* Upper-Permian beds; *3.* Seisian beds; *4.* Campilian beds; *5.* Triassic (?) dolomitic marl; *6.* Upper-Pannonian conglomerate; *7.* Upper-Pannonian sand; *8.* Upper-Pannonian silt; *9.* Upper-Pannonian lignite; *10.* Pleistocene loess.

Kp—3 and To—U/4 have done it in a lower one. The Upper-Pannonian sediments are of clastic origin, deposition of which started by a loose, friable conglomerate in the boreholes Kp—2, 3, by a pebbly sand in the borehole Kp—1, and by a tuffaceous sand in the borehole To—U/4 *(Fig. 2)*. The sequence is composed of sand, locally calcareous sandstone layers with a southward dipping of 3—10° (Plate I, *Fig. 1*; Plate IV, *Fig. 3*). The grain size of the particles are varying but the overwhelming majority of them belongs to the realm of the coarse and medium size classes. The nearshore sequence evidencing for a rapid infilling is interrupted by repeated pebbly inter-beddings of ancient piedmont deltas composed of clastic material produced by abrasion and by creeks with steep slopes and discharging into the basin.

Thus the piedmont lacustrine sedimentation is characterized by an overall occurrence of pebbly intercalations from permanent and periodical water flows as well as from torrential creeks. A loose, very poorly sorted conglomerate with a thickness of several meters has been deposited by this flows and creeks (Plate IV, *Figs. 1—2*). The intensive transporting activity of the torrential creeks is evidenced by these pebbly facies interfingering deeply into the nearshore zone. The lignite seams indicating a periodical appearance of swampy conditions occur in a well-defined stratigraphical horizon, in the lower part of the Upper-Pannonian. Thin silt lenses pinching out laterally are intercalated into the sandy mass of the same interval (SZEDERKÉNYI, T., BARANYAI, I., RÓNAKI, L. 1968].

The Pleistocene is represented by loess with a thickness of 20—30 m and containing *Succineae* remnants characteristic of humid areas.

Sedimentary structures of the marginal sequence

Sedimentary structures of the marginal areas to the sedimentary basin involved are summarized after BALOGH, K. [1971] in the *Table 1.* Within the group of the internal structures, a new form, the so-called "whirl-structures", has been distinguished. Its formation could be explained by the vicinity of the coastline, by the relatively high rate of sedimentation as well as by the turbulent character of the flowing water or mud (=turbidity currents). The sediment deposited in such way is mostly poorly sorted. Being composed grains of different sizes this sediment may have been stirred up periodically by bottom currents even after the deposition.

Due to the rate of the sedimentation and to the close vicinity of the shoreline, the internal-, external- and deformation structures seem to be less frequent in the areas of marginal development as compared to those in the intrabasinal facies.

The nearshore sediments of the marginal areas are characterized by horizontally-laminated bedding, whirl-structures, cross-bedding, ripple-bedding and composite bedding as well as by submarine slumpstructures and/or sediment flows.

Internal structures

a) Horizontal lamination and microlamination evidence for the deposition of the sediment in a nonagitated environment and on equipotential surfaces perpendicular to the gravity. In the Tortyogó-part of the margin of the basin a relatively rapid sedimentation has taken place during the Upper-Pannonian, thus the structures involved could be formed mainly in the upper part of the cycle only, in the periods of less rapid sedimentation (Plate I, *Figs. 1—2*). Similar forms are characteristic of the different stages of the swamp formation, thus the microlamination is frequent in the lignite seams and in the carboniferous shales accompanying them. The horizontal lamination can be studied also in several outcrops nearby the Mecsek-Mts. (e. g.: Hird, Danitz-puszta)

b) The whirl-structures could be identified mainly by poor sorting and by the presence of coarser-finer interbeddings forming irregular-shaped „clouds" in it. Fossil-fragments and shells transported by the turbidity current have also been deposited and buried. These fossil remnants are connected with coarser-finer rocks intervals depending upon their size (Plate I, *Fig. 6;* Plate II, *Fig. 1*); or in other places the coarser particle have washed together forming load structures of defined outlines (Plate I, *Fig. 3*).

The characteristic feature giving the name of this structure is most striking in the case of microscopic photographs, because the whirling effect has been preserved and recorded by the orientation of micas (Plate I, *Fig. 4*; Plate II, *Fig. 2*). Both the overlying and underlying beds of the *Congeria rhomboidea* lumachelle described from the sample recovered from a depth of 249 m in the borehole Kp—3 are characterized by the presence of whirling structures. The dual occurrence of these two phenomena (i. e. lumachelle+whirling structures) evidences a permanent agitation of water. Quartz grains of 1—2 mm in diameter and *Mollusc*-shells of the same size have been buried in the silt (Plate II, *Figs. 3—4*; Plate I, *Fig. 5*; Plate III, *Fig. 1*). Syngenetic and postdepositional (*i. e.* due to the loading effect of the overburden) shell-fracturing could be easily distinguished here (Plate II, *Figs. 5—6*).

The author is of the opinion that the whirl-structures have formed in the nearshore part of the marginal areas, where both the bottom currents caused by discharging fresh-water flows and waves could be active and could remobilize the sediment had already deposited. This structure occure in the lower and upper part of the Upper-Pannonian equally, though is more characteristic of the fine sand- -silt environments. Naturally, in sediments coarser than fine sand this structure could not be detected at all.

c) Cross-bedding has not been observed in the core samples studied by the author, because the structures formed in the deltas of the ancient creeks have been easily destroyed by the abrasion. Delta-like formations, cross-lamination have been reported by WEIN, GY. [1952], while evaluating the core samples recovered from the boreholes of the local water-plant in Tortyogó. It is an interesting reference, because these structures due to the loose texture of the sand stones could hardly be observed in core samples, although it is an widespread phenomenon in the outcrops of the Southern and Eastern parts of the Mecsek Mts. (e. g.: sand quarry of Pécsvárad).

d) The ripple-bedding may develop as a consequence of the pendulum-like motion of the nearshore water. The amplitude, the length and the setting of the ripples is a function of the energy of the moving water. Such structures could be formed here in the less agitated sandy, nearshore zones of the upper part of the Upper-Pannonian series only.

A symmetrical ripple bedding characteristic of marginal, shallow water formations and extending as long as 5—6 m or so in the sand quarry of Hird has been reported and documented by photos as well by KLEB, B. [1973].

e) Composite bedding. A periodical flare up in the activity of currents is recorded by fine sand and coarse silt intercalations, lenses observed in the otherwise well sorted, non-bedded clayey silts. The parallel and non-parallel lamination and the noncontinuous lenticular bedding are general. The more complicated forms of the composite bedding — *i. e.:* continuous lenticular bedding and flaser bedding — are the characteristic features of the intrabasinal facies. It is assumed that in the more distant and deeper environments of the marginal areas even these, more complicated forms could occur but in our samples have not been detected yet.

In the Tortyogó-part of the basin too, the parallel and non-parallel lenticular bedding have been observed in sediments of the periods with less vigorous water-agitation only (Plate III, *Fig. 2*).

External structures

Bioglyphs or biogenic marks have been found in one sample among those studied by the author. On a bedding plane of the fine silt core from a depth of 126 m in the borehole Kp—3, crawling trails and grazing trails (burrows) of mobile mud-eating worms could be observed (Plate III, *Figs. 3—4*). In the sediments of the less vigorously agitated environments of the marginal developments of the Upper-Pannonian in the Middle-Mountain these burrows are so frequently encountered locally (*e. g.:* near lignite seams) that they could be utilised for correlating different horizons [JÁMBOR, Á., KORPÁS-HÓDI, M. 1971].

Tool marks have not been found in the samples studied but in the more remote areas their occurrence could be reasonably postulated because — due to the vicinity of a steep shoreline — different "tools" (boughs, fossils, rock-debris) could get into the deeper part of the basin, where their marks could be easily buried. The formation of the tool marks could be promoted by strong currents, by the far-reaching effects of the waters discharging into the Lake and by the wave-activity of the Lake.

Deformation structures

a) Load structures could be formed at the contact of silt and sand layers of the still plastic underlying beds. Load pouches have been rarely found in the samples from the boreholes in the foredeep of the western part of the Mecsek Mts. only. This fact is due to the relative coarse-grained development of the whole sequence (Plate III, *Fig. 5*).

b) Marks referring to sediment flow, subaqueous slumps have been identified in the sample from a depth of 132,5 m in the borehole Kp—3 (Plate III, *Fig. 6*). More consolidated, fine silt and clay shreds, scales had been intercalated into the coarse silt of these structures. The subaqueous slumping and stirring as well as re-deposition are processes of polygenetic nature [BALOGH, K., 1973]. Currents amplified by subaqueous slumping and, in our case, the far reaching vigorous currents of water-flows discharging in a vary rapid rate into the Lake from the coastal areas might play important role in forming these marks. Though the bottom of the Lake were covered by a rather shallow water at the time of the deposition of this sediment, the vicinity of the shoreline and a small change in the bottom-morphology may have triggered off the slumping of the sediments. It is also kept in mind, that the emerge of the Mecsek-"Island" was being under way. The more clayey silt-shreds, scales have their own internal structure. This phenomenon could be formed also in a lake-bottom covered by plants as a result of currents within the free water masses.

II. THE INTERNAL PART OF THE BASIN: GEOLOGICAL SETTING OF THE ALGYŐ-SZEGED AREA

The NW—SE striking elevated blocks of the Algyő and Szeged areas are parts of a buried ridge which could be followed in the southern part of the Great Hungarian Plain. This ridge has Carboniferous (?) and Triassic beds overlying the Paleozoic crystalline basement. The blocks of the Pre-Tertiary basement — islands of different areal extent — separated the different part-basins encircled by them.

The block of Szeged has already been inundated during the Middle-Miocene transgression and formed a submarine ridge only during the Lower-Pannonian. In contrary, the crystalline block of Algyő — excepting its western flank — still existed as an island area even at the beginning of the Lower-Pannonian [BALOGH, K., 1973].

Above the blocks being in a structurally higher position as compared to their environ, the compaction of the thick Pliocene sedimentary series has formed a number of hydrocarbon-bearing growth-anticlines showing a gradually decreasing dip upwards *(Fig. 3)*.

The eastern, Algyő-block is composed of metamorphic rocks entirely. In contrary, in Szeged, the basement of the Tertiary basin consists of Carboniferous (?) breccia, Lower-Triassic quartzose sandstone and Middle-Triassic brecciated dolomite all of them overlying the metamorphic rocks being in a deeper structural position by as much as several hundred meters as compared to the same metamorphic basement in Algyő. The coarse-grained abrasion conglomerate of the transgressive Tortonian sea inundating the former island after a considerable period of erosion could be followed up in the western flank of the Algyő-structure only. In Szeged, however, the much more finer, sandy, marly sediments overlying this coarse conglomerate series occur too, referring to a gradual moving off the shoreline.

A Lower-Pannonian basal conglomerate has deposited mostly in the margins of the metamorphic ridges of Algyő still in an elevated position at that time. The several m thick sandstone, dark marl and limy marl series overlying the conglomerate evidences for the rapid subsidence of the former island. This transgressive sequence is composed of clayey marl—marl beds, more upward sandstone layers and finally sandstone-clayey marl layers [KŐRÖSSY, L., 1971].

The Lower-Pannonian basal conglomerate is missing in Szeged, the sedimentation of this substage starts with the deposition of a marl-limy marl series here.

The mean thickness of the Lower-Pannonian in Algyő is as much as 600 m and amounts to 1000 m in the flanks. In Szeged-trough the limy—marl horizon is relatively thin showing a thickness of several ten meters — the mean thickness of the Lower-Pannonian varies between 600—900 m.

The Upper-Pannonian sedimentation forms the regressive phase of the Pannonian cycle. This may be due to the Rhodanian phase of the Alpine orogeny.

The shallow lacustrine Upper-Pannonian sequence consists of a variation of rhythms composed of sandstone-clayey marl, lignite. In addition, periods of more and less rapid sedimentation change each other.

The total thickness of the Upper-Pannonian in Algyő amounts to 1200—1500 m. This series consists of a variation of sand, sandstones and clayey-marl as well as lignite ribbons with a thickness of several decimeter, and silt. In Szeged, the Upper-Pannonian could be found in depth interval of 600—1950 m b. s. l.

The fluviatile Upper-Pliocene generally in a depth of 300—750 m b. s. l. consists of the variation of clay and sand.

The Upper-Pliocene beds are overlain by a Pleistocene-Holocene series of aeolian—fluviatile origin [T. KOVÁCS, G., 1973; VÖLGYI, L., SUBA, S., BALLA, K., CSALAGOVITS, I., 1970].

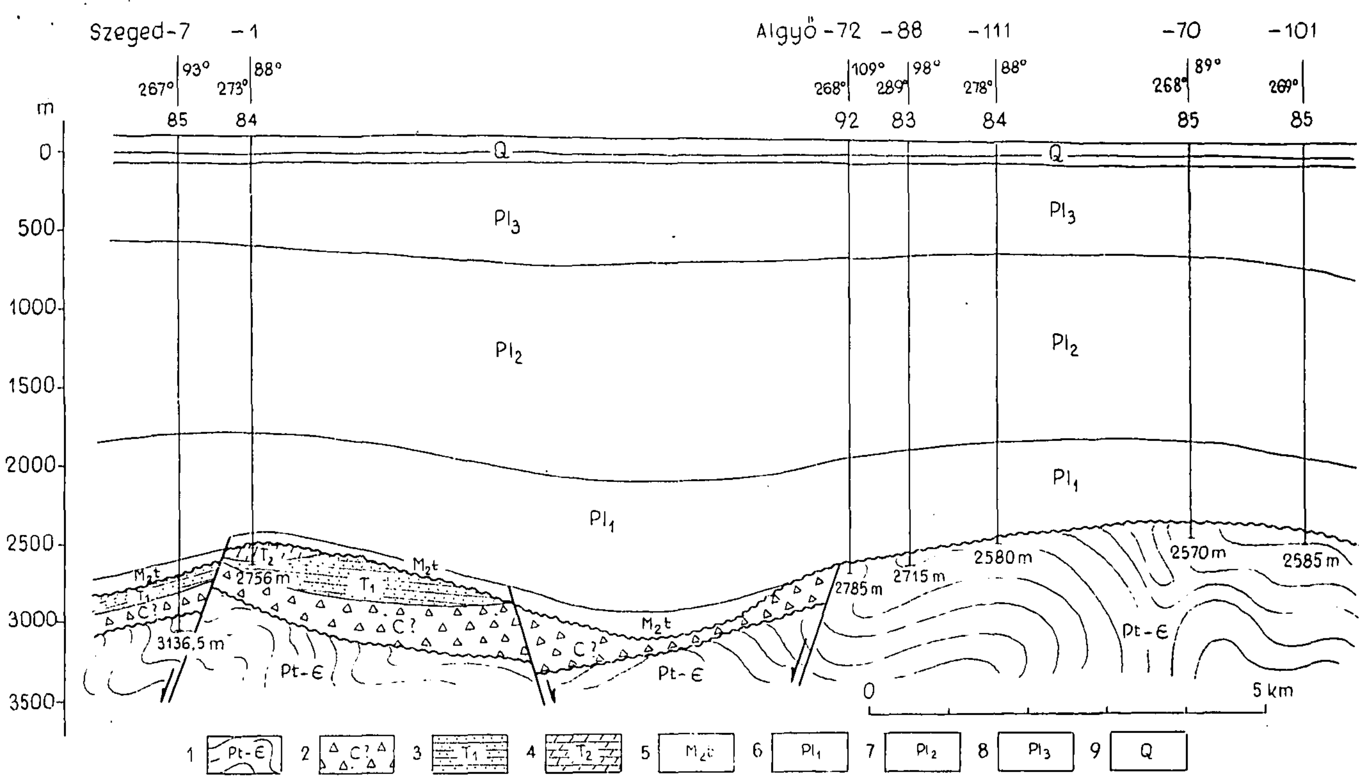

Fig. 3. Geological profile between the boreholes Szeged—7 and Algyő—101 [After T. KOVÁCS, G., 1973]. *1.* Precambrian and Early-Paleozoic metamorphic rocks. *2.* Carboniferous (?) breccia; *3.* Lower-Triassic sandstone; *4.* Middle-Triassic dolomite; *5.* Miocene; *6.* Lower-Pannonian; *7.* Upper-Pannonian; *8.* Upper-Pliocene; *9.* Holocene-Pleistocene.

TABLE 1

Frequency of occurrence of the sedimentary structures of the marginal and intrabasinal Upper-Pannonian sediments

	I. Internal structures						II. External structures		III. Deformational structures				
	Horizontally parallel lamination, microlamination	Graded bedding	Whirl structures	Cross bedding	Ripple bedding	Composite bedding [lenticular bedding, composite ripple bedding]	Bioglyphs	Mechanoglyphs	Load structures	Growth fault	Sand injections	Convolution	Sediment flow, subaqueous slumping
Marginal development	Frequent in the coal-bearing clays accompanying the lignite beds in the upper part of the Upper-Pannonian cycle	—	Charac-teristic	Frequent in the outcrops of the eastern and southeastern part of the Mecsek foreground	Occurs	Occurs	Occurs	—	Rare	—	—	—	Occurs
Intrabasinal development	Characteristic	Frequent	Very scarce	Frequent	Frequent	Charac-theristic	Frequent	Occurs	Charac-teristic	Occurs	Very scarce	Frequent	Frequent

The sedimentary structures of the intrabasinal sequence

The intrabasinal Upper-Pannonian sequence is much more aboundant in sedimentary structures as compared to the marginal facies *(Table 1)*. External, internal and deformational structures can be found equally, excepting the whirl structures known in the marginal areas only.

The description and analysis of sedimentary structures of 144 Upper-Pannonian samples is a result of a work lasting for years [BALOGH, K. *et al.*, 1968, 1969, 1972]. The core samples represent the lower part of the Upper-Pannonian; they have been recovered from the intervals of 1840—2080 m and 1600—1770 m in Algyő and Szeged respectively; i. e. they comprise the most intensively explored, 150—250 m thick interval of the sandstone—siltstone series.

Internal structures

After the relatively balanced sedimentation of the Lower-Pannonian started a period of variable shallow-lacustrine sedimentation. The characteristics of the sediment accumulation in the different part-basins with a different rate of subsidence were controlled by the energy and turbulency conditions of the currents dominating there.

a) Series of layers varying in thickness of several mm-s to several cm-s or so and characterized by horizontal or slightly rippled, parallel lamination, microlamination are marked mostly by differences in the grain size composition, by the simple sorting of the beds, by the orientation of mica-scales as well as by differences in colour caused by the organic substances of floral origin in it (Plate IV, *Figs. 4—5*; Plate V, *Fig. 2*). The carboniferous, microlaminated clay and silt found locally, has deposited in a depth interval of the shallow lake characterized by the total absence of the waves (Plate IV, *Fig. 4*), where the sedimentation was a periodical phenomenon only. In the case of the carboniferous slate an autochtonous swamp existing in a well-defined period only should be postulated.

Thin beds mostly form a series of small rhythms with a continuous transition between the rhythmunits (Plate V, *Fig. 1*). The horizontal-parallel lamination has also been observed as one of the elements of the composite bedding intercalated into sand ripples and silt layers (Plate IV, *Fig. 7*; Plate VI, *Figs. 3, 6*). Well-sorted, fine grained sandstones with a network of thin coal seams (ribbons) in a horizontal rippled-parallel position are extremely frequently encountered (Plate VI, *Fig. 4*).

b) Graded bedding. In the silt and fine sand layers simple sorting has been observed so far, which refers to the gradual decrease in the energy level of the turbidity current. In the case of fine-grained sediments the graded bedding accompanied by fine horizontal lamination forms a composite bedding, the finely laminated part of which settles down from the least dense suspension of the turbidity current [BALOGH, K., 1971; Plate V, *Fig. 1*]. By moving offshore the graded bedding becomes more completed.

c) Cross bedding. Cross bedded sand ripples of the shallow sublittoral zone with an amplitude of 1—4 cm or so, and with a maximum length of 10—15 cm are frequently found in the saples studied. Their small scale refers to the low energy level of the bottom current tracting them. Different erosion phases of the sand ripples climbing on the bottom could be observed (Pláte IV, *Fig. 6*). The erosion was triggered off by an abrupt change in the direction or velocity of the current. The set of the cross bedded sand ripples are mostly composed of beds with varying orientation (Plate IV, *Fig. 7*). The fine beds of the sand ripples are characterized by a sorting value reflecting the changes in the current velocity as well as by an accumulation of the clay-silt and mica scales (Plate VI, *Figs. 1—2*). The dip of the beds amounts to 8—10—25°.

d) Ripple bedding. If the partially eroded sand ripple are separated by clay flasers (Plate IV, *Fig. 8*) a ripple bedding develops.

e) The composite bedding is formed by addition of two or more bedding forms. Its development is due to currents of different energy level and orientation. A variation of horizontally and crosslaminated beds is a phenomenon of fairly frequent occurrence (Plate IV, *Fig. 7*; Plate VI, *Fig. 3*).

Both forms of the lenticular bedding — the discontinuous and continuous one — could be observed equally (Plate IV, *Fig. 6*).

A part of sand lenses in silt beds could be considered as remnants of subsided sand ripples.

In the silts seemingly almost entirely homogenous, coarser and finer interbeddings, lenses of several mm to cm or so in size respectively are frequent (Plate VI, *Fig. 5*).

External structures

On the bedding planes of clayey silts or fine sandstones bioglyphs of meandering form are frequent. This sections prepared from samples perpendicular to the bedding show traces of some burrowing, mud-eating and mud-dwelling organisms clearly. Locally, these burrows of 1—10 mm in size show a massive appearance upon or within a beding plane. The microlaminated sediments mostly with large volume of organic substances and with non-agitated environments assured an ideal condition for benthonic organisms (Plate VII, *Figs. 1, 3*). In microphotographs, they occur as well-bedded fillings or — in fine grained sediments — as cylindric or trough-shaped fillings with definite outlines and composed of coarser grains (Plate VII, *Figs. 2, 4*).

Massive accumulation of well-preserved *Mollusca*-macrofauna could be only rarely observed in the sediments of the inner parts of the basin. Even some parts of the calcareous shell of *Limnocardium schmidti* [M. HÖRN.], *Congeria cžjžeki* M. HÖRN. *Dreissena sp.* are preserved on the stones recovered from the interval 1960—1961 m below the surface in the borehole Algyő—454. The orientation of the fossils here refer to a rapid burial and drift; thus their traces are of rather indistinct appearance (Plate VIII, *Fig. 5*).

The mechanoglyphs are represented by gullies and channels on the surface of silts and sand ripples. These evidence for an increase in energy level and re-suspension as well as further transportation of the sediments had already been deposited (Plate VI, *Fig. 4*). This phenomenon accounts also for the eroded sand ripples of samples with composite bedding (Plate IV, *Fig. 6*).

Deformation structures

a) The load structures are extremely characteristic of the finer sediments of the intrabasinal Lower and Upper-Pannonian. Their presence shows that — due to the differentiated load — some part of the coarser sand bed or sand ripple deposited upon the surface of the still plastic fine mud may have been submerged into it. This submerge may has been promoted by some shocking effects (earthquakes or microseismic activity of local extend).

As a result of mud-deformation, downwards load pockets and load sacks, upwards and beside the former forms flames-tructures of silty substance were formed. Their are of several mm to several cm or so in size (Plate VII, *Fig. 5*), and are almost present in any bedding plane of samples composed of silt and sand interbedding. In microscope, the sharp contact of the two sediments of different grain size are always striking (Plate VII, *Fig. 6*).

b) The sedimentary faults are considered as shearing planes penecontemporaneous to the sedimentation. They are more frequent in the Lower-Pannonian, but less frequent in the silts and fine sands of the Upper-Pannonian. They show a displacement of some mm or cm or so, without any continuation upwards or downwards (Plate VIII, *Fig. 1*).

c) Sand injections. They developed as a result of liquefaction in the sediments in a form of sandstone or silt injections with a size of 1—2 mm or so.

d) Convolution. This is a phenomenon of frequent occurrence in the sequence composed of silt and sandstone interbedding in the lower part of the Upper-Pannonian. This structure may have been developed by the crest-deformation of the submerged sand ripples or by liquefaction triggered off by chocking effect of earthquake waves. An impressive example of sand ripples submerging into silt is shown in the *Fig. 2* of Plate VIII. The structures had been formed earlier sometimes might be subjected to dragging effect too.

e) Slumping and sediment flow take place if — due to a sudden impulse — the loose sediment deposited on the uneven slope of the bottom starts to move. This phenomenon show a widespread occurrence in the Upper-Pannonian as a result of the frequent crust movements. Chaotic folded structures of silt and fine sand due to mud movement are shown in the *Fig. 3* of the Plate VIII. In microscope, the sediment of different grain size folded mutually into each other are separated by a sharp contact; sometimes even the fade traces of their primary bedding can be perceived (Plate VIII, *Fig. 4*).

The silt scales, "pancakes" and pebbles in sandstone are also in connection with the water movement after the slumping. New and new pieces were torn up and transported further by the currents from the more consolidated silt shreds which had been torn up earlier due to the slumping. These shreds (or if they are slightly rounded: pebbles) preserve their inner structure. Their size is several mm to cm or so (Plate VIII, *Fig. 6*).

III. COMPARISON OF THE SEDIMENTOLOGY AND HISTORY OF THE MARGINAL AND INTRABASINAL SEQUENCES STUDIED

The Pannonian Lake reached its largest areal extension during the Upper-Pannonian. The water table of the Lake getting more and more fresh has fallen into different parts. Thus, by the lapse of time a continuous decrease in the distance from the shores can be considered. While the development of the Early-Neogene intrabasinal and marginal sediments had been substantially different due to the shoreline pattern, to the extension and slope conditions of the drainage area and to the relief of the bottom of the sedimentary basin, during the Upper-Pannonian—when nearshore conditions were dominant both in Transdanubia and in the Great Hungarian Plain — the faciesspectrum became much more simple: a nearshore environment and a neritic zone could be distinguished on the basis of biofacies.

Due to the lack of any comprehensive study, the paleogeography of the Mecsek Mts. and the Upper-Pannonian in Algyő—Szeged could be inserted as small mosaics only in the evolutional sequence of the Pannonian. By comparing the different sets of layers the following facts could be stated:

1. The lithological differences in the series involved are connected with the development of their sedimentary basin different in time and space. The Upper-Pannonian in the foredeep of the Western Mecsek Mts. inundated the basement complex, meanwhile in the Szeged—Algyő area the sedimentation had been in progress since the Miocene or Lower-Pannonian, respectively. Due to the crust movements at the border of the Lower/Upper-Pannonian infilling of the sedimentary basin started with coarser sediments. The sediments of the two areas involved are differing in their grain size, sorting, rounding and mineral composition.

While the sedimentary sequence in the Mecsek foreground keeps to be coarse grained during the whole Upper-Pannonian cycle (pebble, coarse and medium sand, sandstone) and the sediments becomes finer at the end of the infilling in some swampy periods only, the neritic sequence is, however, characterized by the dominance of finer sediments during all the cycle. The rocks of the Algyő area are well sorted, the sediments of the nearshore sequence, however, are marked by their poor sorting.

The $CaCO_3$ content of these two areas are highly different. The sedimentary sequence of the foredeep is almost totally carbonate-free — excepting the psefitic rocks and some more carbonaceous sandstone banks. The carbonate content of the intrabasinal set is relatively high, independently of the grain size.

The Upper-Pannonian of the Mecsek foredeep being very close to the shoreline forms a regressive half-cycle extending from a coarse conglomerate to the fine silt-clay.

The intrabasinal Upper-Pannonian sequence, however, could be devided into several smaller cycles as it was revealed by MOLNÁR, B. [1965] at first for the upper part of this sequence. The hydrocarbon exploring boreholes in Algyő—Szeged, however, recovered core samples from the lowest part of the Upper-Pannonian only. Several regressive halfrhythms have been reported from these samples by MUCSI, M., RÉVÉSZ, I. [1968, 1975] and by MUCSI, M. [1973].

2. The sedimentary structures of the intrabasinal and marginal sequences are summarized in the *Table 1.*

Due to the vicinity of the sleep coast, to the more rapid rate of sedimentation, to the coarser grain size, the marginal development is much less aboundant in internal, external and deformation structures as compared to the intrabasinal one. The formations here are characterized by horizontal-parallel lamination, whirl-structures, the more simple forms of the cross bedding, ripple bedding and composite bedding. The whirl-structures are the special features of the nearshore sedimentation and are considered as results of turbidity currents and of vigorously agitated water.

The sedimentary structures of the intrabasinal sequence of layers, however, are more different in forms and they are more frequently encountered as compared to those in the sediments on the steep coast. The finer grain size and the more considerable distance from the shoreline were favourable factors for the formation of internal structures. This shallow lacustrine set of less agitated water is dominated by the different forms of the horizontal-parallel lamination, graded bedding, cross-bedding and composite bedding.

The fine-grained sediments of the ancient lakebottom have recorded a considerable number of trace fossils and marks of deformation processes in micro- and macro-size. Due to the low energy level of the bottom currents and to the considerable distance from the shoreline, whirl structures can be found in this region very scarcely.

The flowing and waving activity of the shallow lake have developed small scale forms — cm to dm in order of magnitude — only in the fine mud of the bottom.

SUMMARY

1. The sediments of the steep coast in the SW-Mecsek Mts. are poorly sorted and mostly non-bedded due to the rapid sedimentation and re-deposition. The horizontal bedding as well as the whirl-structures characteristic of the well-agitated water and the composite bedding appear by moving offshore only. The intrabasinal environment near Szeged is dominated by horizontal-parallel lamination, cross- and graded bedding. The surficial or deformation structures are most frequent here as well.

2. The so-called "whirl-structure" characteristic of the marginal sediments only has been distinguished here as a new form within the group of the internal structures.

3. The sediments of the intrabasinal Upper-Pannonian series in Algyő—Szeged refer to a sediment accumulation in a more balanced condition: the grain size of the sediments deposited here varies between clay and fine sand. The fossil plant remnants and the fine and medium size pebbles accompanying silt have deposited in the foreset part of a large delta being formed in an open lake and showing a considerable variation of sedimentary structures.

4. The Keresztespuszta-Tortyogó area of steep coast environment have been in a „channel" connecting the big sedimentary basins in Transdanubia and in the Great Hungarian Plane and being in the direction of the faunal migration as well.

The Algyő—Szeged area, however, belonged to the larger Neogene basin with large areas of open water in the Southern Part of the Great Hungarian plain.

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EXPLANATION OF PLATES

PLATE I

Sedimentary structures of the marginal sediments:

Fig. 1. Horizontal, parallel micro-laminae of fine sand. The beds are marked by limonite accumulation. — Polished surface section. — Borehole Keresztespuszta—3, 187,2 m

Fig. 2. A 0,2—5 mm thick limonitic ribbon in fine sand bearing silt with a postdepositional and perhaps postdiagenetical connection to the more clayey bed. — Borehole Keresztespuszta—3, 57,8 m — 1 N — 22x.

Fig. 3. Whirl structures formed by rounded sandy silt clay and Mollusca-shell debris with an irregular diagonal section in silt. — Polished surface section. — Borehole Keresztespuszta—3, 138,5 m

Fig. 4. Whirl-structures in coarse silt. The oval form of the structures is shown by the orientation of micas. — Borehole Keresztespuszta—3, 53,0 m — 1 N — 22x

Fig. 5. A lumachelle composed of shell fragments of young individuals of *Gastropoda, Congeria* and *Limnocardium* in fine sand bearing silt with whirl-structure. — Borehole Keresztespuszta—3, 249,0 m/3 — 1 N— 22 x

Fig. 6. Silt showing whirl-structure and containing shell fragments of *Limnocardium* and *Congeria.* — Polished surface section. — Borehole Keresztespuszta—3, 249,0 m/4

PLATE II

Sedimentary structures of the marginal sediments:

Fig. 1. Lenticular and whirling silt having *Limnocardium* and *Congeria* shell fragments. — Polished surface section. — Borehole Keresztespuszta—3, 260,0 m/2

Fig. 2. Whirl structures in clayey silt. — Borehole Keresztespuszta—3, 70,2 m — 1 N — 22x

Fig. 3. Lumachelle of *Congeria* shells in fine sand bearing silt. — Borehole Keresztespuszta—3, 249,0 m

Fig. 4. A lumachelle of *Congeria rhomboidea* M. Hörn. with inprint of *Pteradacna pterophora* Brus. marked by the arrow. — Borehole Keresztespuszta—3, 249,0 m/2

Figs. 5—6. Fractured *Congeria* and *Limnocardium* shells washed together and intercalated into a fine sand bearing silt with a whirl structure. — While the shell-fracturing in the *Fig. 6* are of postdiagenetic character and caused by the load of the overburden, the fracturing in the *Fig.5* are of contemporaneous to the deposition. — Borehole Keresztespuszta—3, 249,0 m/3 — 1N — 22x

PLATE III

Sedimentary structures of the marginal sediments:

Fig. 1. Whirl structure in a fine sand bearing silt. The thin *Mollusca*-shell sustained the coarser grains as a watch-glass. — Borehole Keresztespuszta—3, 249,0 m/3 — 1 N — 22x

Fig. 2. Parallel, non-continuous lenticular bedding in silt. — Polished surface section. — Borehole Keresztespuszta—3, 270,0 m

Figs. 3—4. Silt filled worm burrows with rounded diagonal section and irregularly shaped longitudinal extension. — Borehole Keresztespuszta—3, 126,0 m

Fig. 5. Load pocket at a sandstone-silt contact. — Borehole Keresztespuszta—3, 42,7 m — 1 N — 22x

Fig. 6. A sample composed of sediment components of various grain size and formed by a subaqueous slumping. — Polished surface section. — Borehole Keresztespuszta—3, 132,5 m

PLATE IV

Figs. 1—3. Sedimentary structures of the marginal sediments:
Figs. 4—8. Sedimentary structures of the marginal sediments:

Fig. 1. Non-sorted loose conglomerate cemented by medium grained sandstone. — Sediment of a torrential creek. — Borehole Keresztespuszta—3, 286,0 m

Fig. 2. The texture of a loose conglomerate consisting of quartzite debris mainly. — Sediment of a torrential creek. — Borehole Keresztespuszta—3, 285,0 m — +N — 22x

Fig. 3. Fine sandstones consisting of sharp-edged quartz and quartzite grains cemented by calcareous material. The sandstone has a pebble of 2 mm in diameter too. — Borehole Keresztespuszta—3, 196,8 m — 1 N — 22x

Fig. 4. An interbedding of horizontal micro-laminae of clay and silt. — The majority of the laminae are simply sorted, their finishing element is clay or carboniferous silt. — Borehole Szeged—11/18: 1615,20—1615,31 m

Fig. 5. Fine sand showing a horizontal parallel microlamination. — Polished sufrace section. — Borehole Algyő—231; 1/5: 1911,42—1911,50 m

Fig. 6. An interbedding of cross-bedded sand ripples and silt showing composite [continuous lenticular] bedding. — The sand ripples have been eroded in some places. — Borheole Algyő—211;1/3: 1886,90—1887,03 m

Fig. 7. An interbedding of cross bedded sand ripples and silt showing horizontal parallel and parallel ripple bedding. — Polished surface section. — Borehole Algyő—231; 1/9: 1915,50—1915,70 m

Fig. 8. An interbedding of carboniferous silt and non-parallel, ripplied, microlaminated and cross-bedded sandstone. — Borehole Szeged—1; 1/8: 1605,08—1605,26 m

PLATE V

Sedimentary structures of intrabasinal sediments:

Fig. 1. A series of small rhythms consisting of coarse silts and fine sandstone showing simple sorting. — 5 small rhythms could be observed in the photographs. — Borehole Algyő—247; 1/9: 1956,19—1956,35 m — 1 N — 22x

Fig. 2. The series of photographs showing the stratification pattern of a horizontally laminated silt. — The clayey fine silt is overlain by a coarse silt with fine sand. The upper part consists of interbedding of silt beds with coal ribbons. — Borehole Szeged—1; 1/16: 1614,60—1614,65 m —1 N — 15x

PLATE VI

Sedimentary structures of intrabasinal sediments:

Fig. 1. Lamellae with a dip of 8—10° of a cross-bedded sand ripple pinching out gradually. — The final part of each is aboundant in clay and mica. — Borehole Algyő—231; 1/9: 1915,50—1915,70 m — 1 N — 12x

Fig. 2. Horizontally microlaminated fine-grained sandstone overlain by a cross-bedded sand ripple. — There is an unconformity of 25° at the contact of the two beds, whick is illustrated by the orientation of the mica scales. — Borehole Algyő—241; 6/3: 2023,11—2023,30 m — 1 N — 22x

Fig. 3. A sample of composite bedding consisting of interbedding of horizontally and cross laminated set of beds. — The microlamination is shown by carbonized fossil plant debris accumulated in form of ribbons with a thickness of 0,1—5 mm or so. — Borehole Algyő—241; 6/3: 2023,11—2023,30 m.

Fig. 4. The contact of a non-bedded sandstone with pebbles of fine sandstone and fine sand having a network of coal-bearing ribbons and lenses. — The coal-bearing sandstone shows continuous ripple bedding with a slightly eroded interface. — Borehole Algyő—216; 1/10—1/11: 1926,74—1926,85 m

Fig. 5. 2,5 mm long lense parallel to the bedding plane in a horizontally micro-laminated silt. — Borehole Szeged—9; 4/16: 1765,00—1765,10 — 1 N — 22x

Fig. 6. Interbedding of horizontal parallel microlaminae of sandstone and silt. — The slightly ripple looking surface of the thicker sand beds refers their sand ripple nature. — Borehole Algyő—247; 1/9: 1956,19—1956,35 m

PLATE VII

Sedimentary structures of intrabasinal sediments:

Fig. 1. Well-sorted micro-laminated, rippled-microlaminated coarse and fine silt with bioturbations. — There is an oblique outwash plane in the middle of the sample. — Borehole Szeged—1; 1/12: 1611,64—1611,82 m

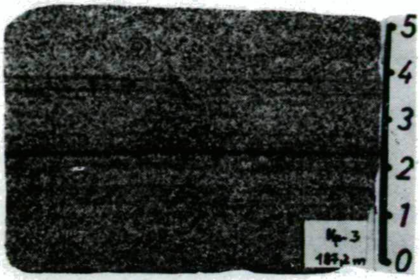
Fig. 2. Worm-burrow filled by coarse silt in a parallelly microlaminated coal-bearing silt. — Borehole Szeged—1; 1/16: 1614,60—1614,65 m — 1 N — 22x

Fig. 3. Well-sorted fine silt and sandstone with bioturbation. — Polished surface section. — Borehole Szeged—1; 1/12: 1611,18—1611, 30m
Fig. 4. Trail of a burrowing filled by fine sand, on the bedding plane of a claystone. — Borehole Algyő—242; 2/3: 1967,93—1968,17 m — 1 N — 22x
Fig. 5. Convolute load pouch subsided into silt and accompanied by a silt flame structures. — Borehole Algyő—241; 5/4: 1992,5 m
Fig. 6. Load pocket at a contact of clay and silt showing parallel microlamination. — Borehole Szeged—1; 1/16: 1614,60—1614,65 m — 1 N — 22x

PLATE VIII

Sedimentary structures of intrabasinal sediments:

Fig. 1. A 0,4—0,9 mm thick fine sandstone lamina thrown by a small sedimentary fault in silty clay. — Borehole Szeged—1; 1/14: 1612,92—1613,02 m — 1 N — 22x
Fig. 2. Convolute sand ripples subsided into silt. — Borehole Algyő—242; 2/2: 1965 m
Fig. 3. Trace of mud movement in fine sand bearing silt. — Borehole Algyő—241; 7/2: 2059,34—2059,60 m
Fig. 4. A part of fine sandstone lamina curved and folded into silt by mud movement. — Borehole Algyő—247; 1/5: 1945,16—1945,45 m — 1 N — 22x
Fig. 5. A massive occurrence of *Limnocardium schmidti* [M. Hörn.], and *Congeria cžjžeki* M. Hörn. in fine sandstone. — Borehole Algyő—454; 2: 1960,0—1961,0 m
Fig. 6. Clay lense torn up by mud movement in silt. — Borehole Algyő—241; 7/2: 2059,34—2059,60 m — 1 N — 22x



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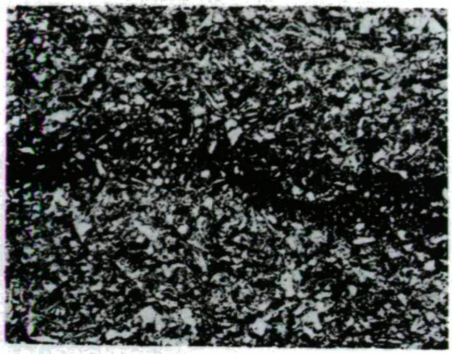

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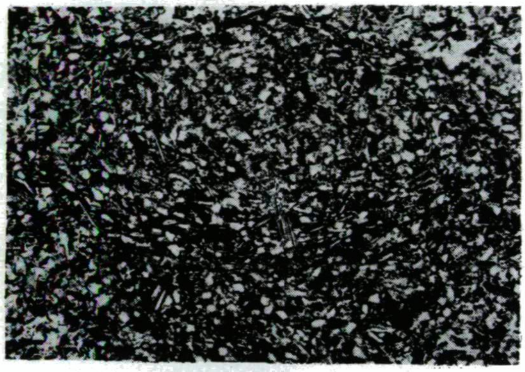

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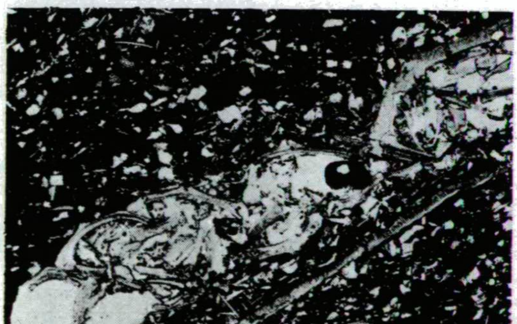

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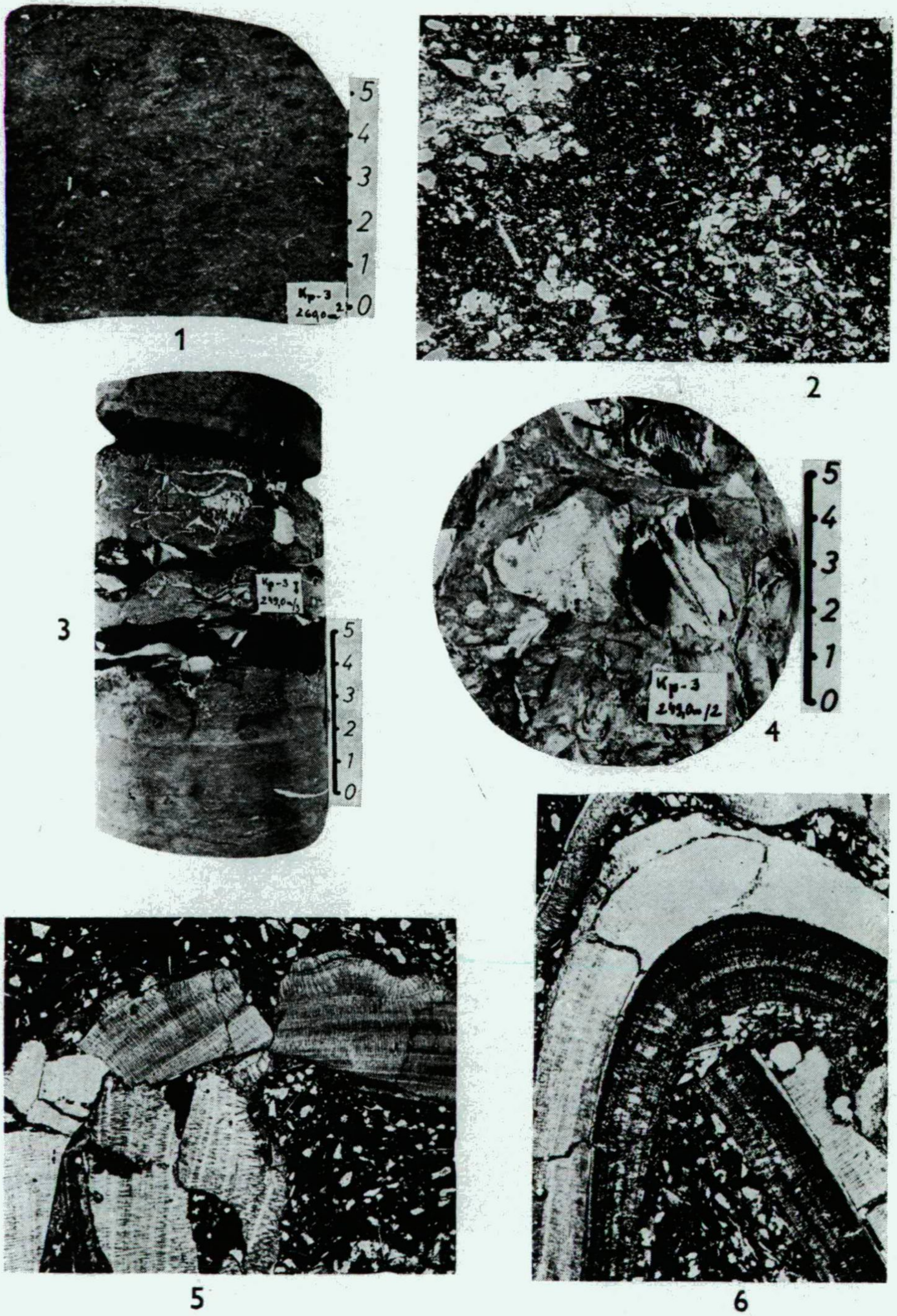
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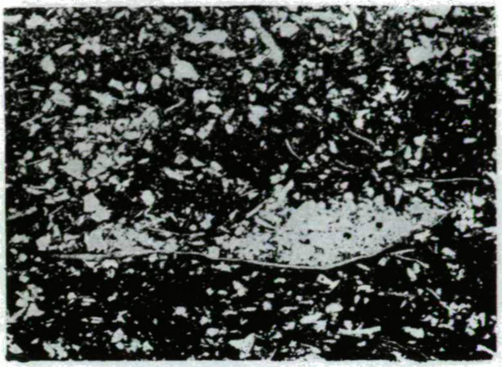

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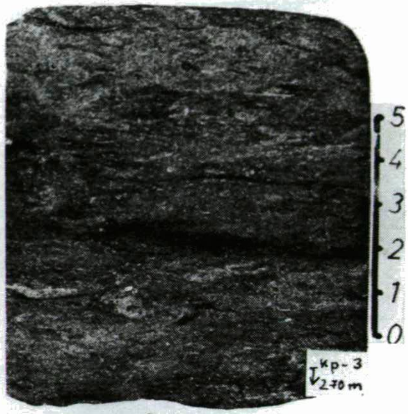

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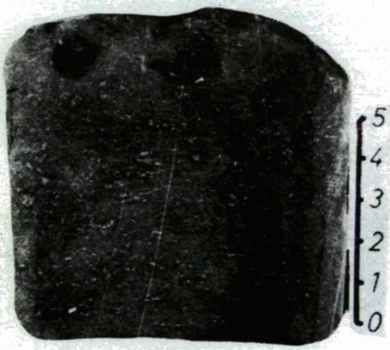

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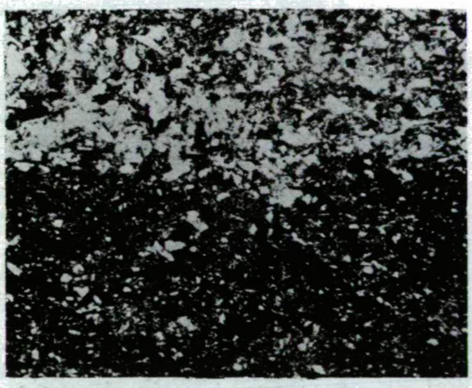

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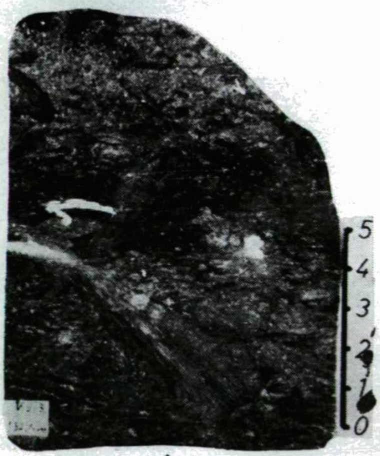

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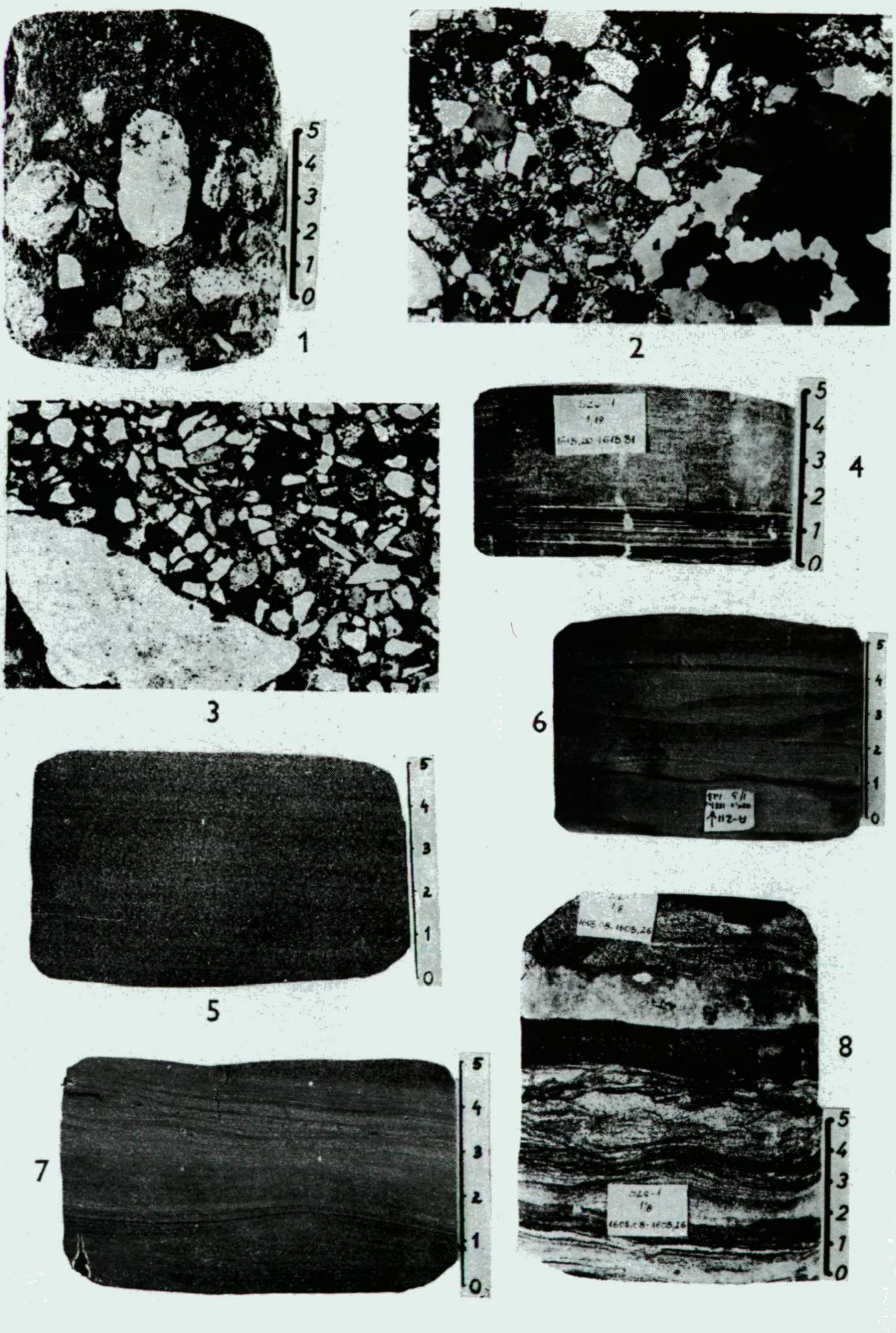
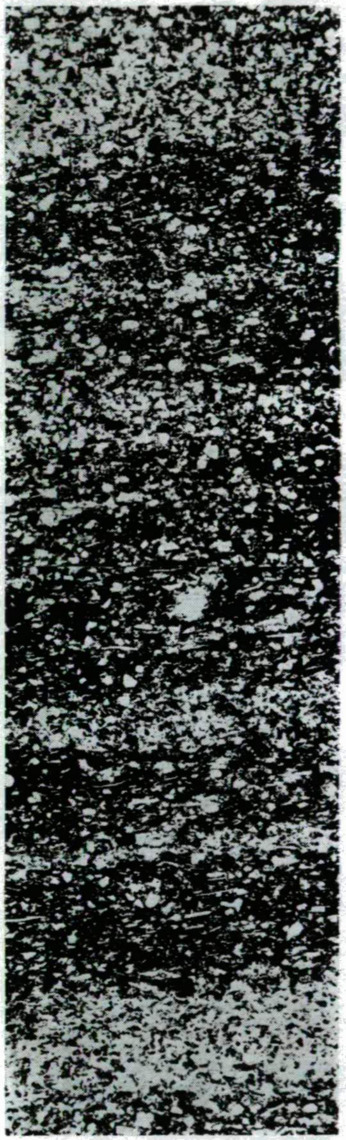
PLATE IV





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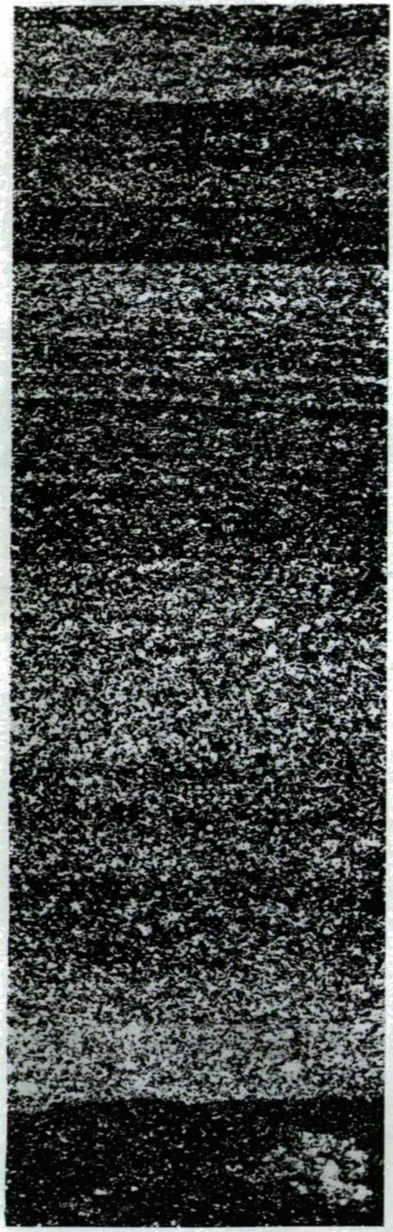

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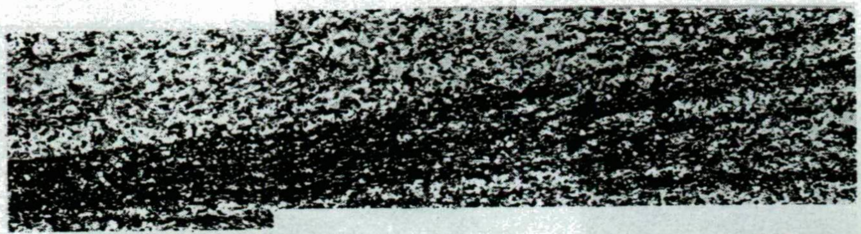
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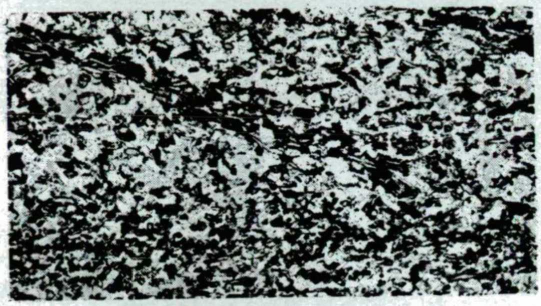
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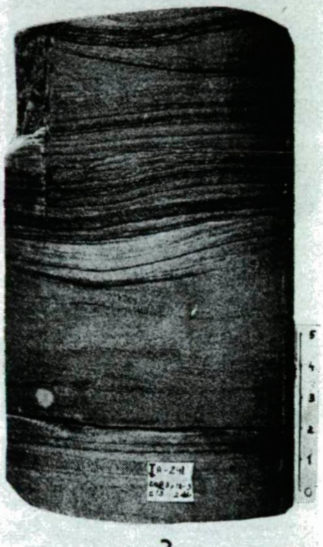
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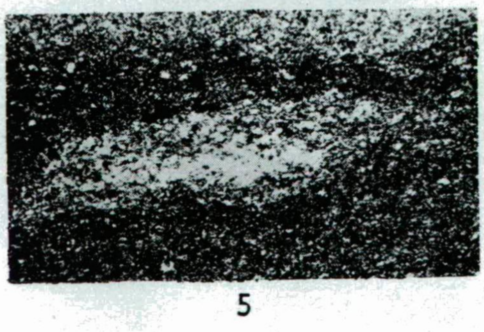
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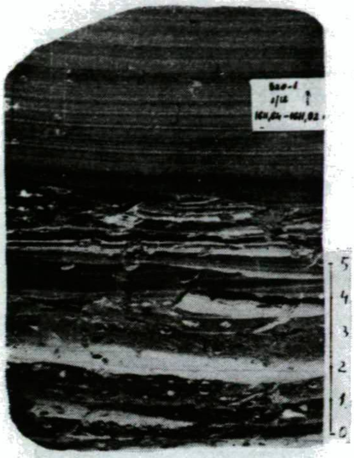

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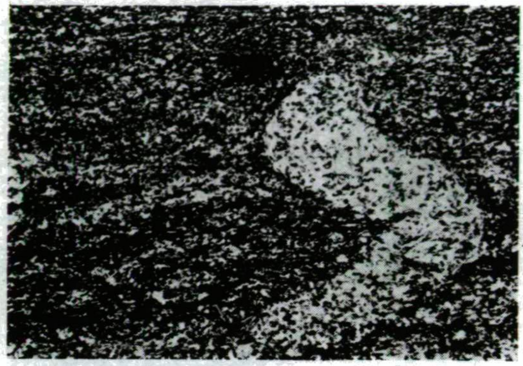

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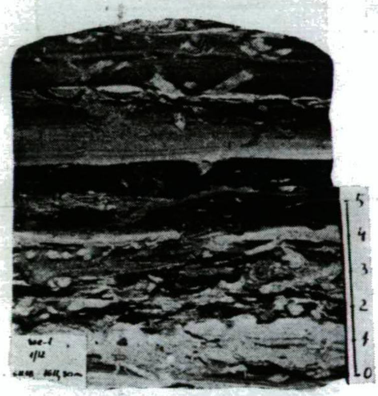

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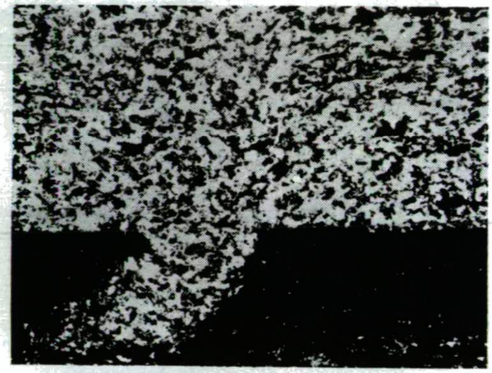

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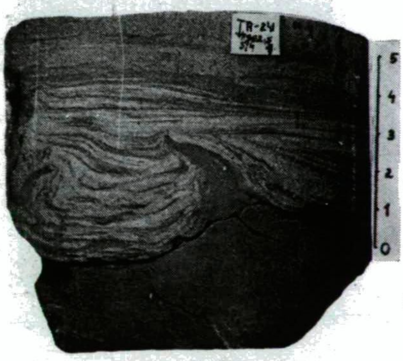

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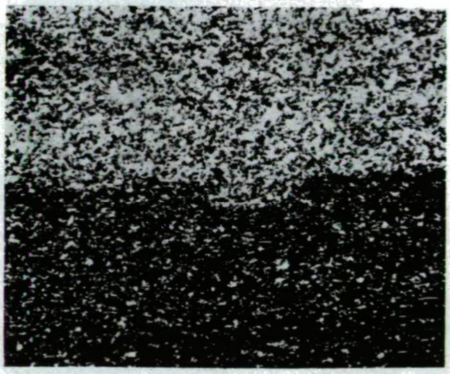

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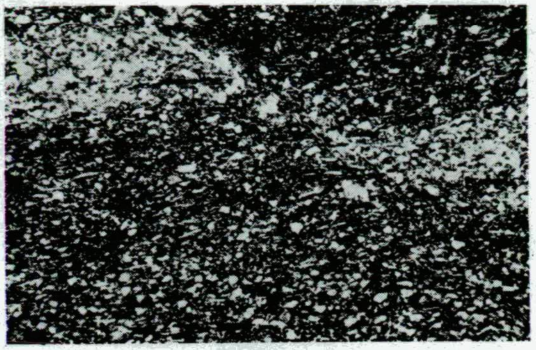

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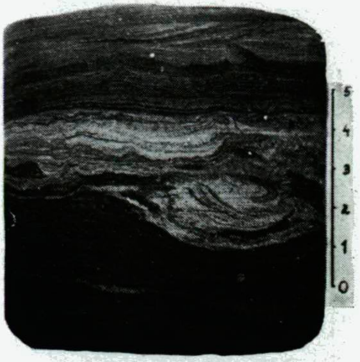

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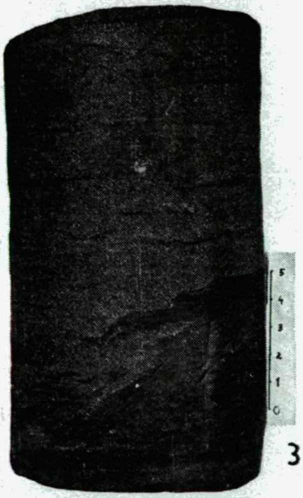

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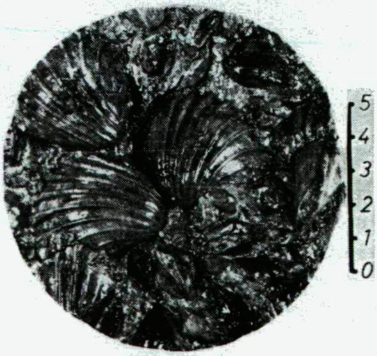

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Acta Mineralogica-Petrographica, Szeged, XXII/2, 267—283, 1976

DATA ON THE CLASSIFICATION OF PANNONIAN SEDIMENTS OF THE ALGYŐ AREA

L. MAGYAR and I. RÉVÉSZ

ABSTRACT

This study deals with the outlined classification of the Pannonian sediments of the Algyő anticline being an intra-basin area explored most accurately by hydrocarbon prospecting bores in Hungary.

INTRODUCTION

The basement of the anticline of NW—SE strike lying northeast of the town Szeged (South Hungary) consists of Paleozoic and Precambrian metamorphites and locally of Middle Triassic dolomite. These are overlain by Neogene and Quaternary of about 2500 to 3500 m thickness. Disregarding the Miocene found only in a few bores the Pannonian sequences forms the thickest complex of the area. Its thickness varies between 1700 and 2500 metres *(Fig. 1)*.

On the area in question data were referred to by V. DANK [1965], L. VÖLGYI [1965], M. SZÉLES (1962, 1966, 1968*a*, 1968*c*, 1971] and L. KŐRÖSSY [1968, 1971].

Our elaboration contains the data of about 450 bores of incomplete core sampling, out of them 100 were drilled down to the basement, the others only down to the boundary of the Lower and Upper Pannonian. In the work the practical bore documentation was also used. The fauna determinations were carried out partly in the laboratory of Budapest of the OKGT OGIL (Oil and Gas-Industrial Laboratory), partly in the Department for Material Testing of the OKGT NKFÜ. Disregarding the accessory elements the species found were summarized in tables *(Figs. 2—6)*. One occurrence denotes one bore. Since in case of determination the piece number of each species was not given, in the figures often only estimated piece numbers are found *(Figs. 3* and *5)*. This, however, does not essentially influence the determination of the dominancy conditions *(Fig. 6)*. When adding 82 m in average to the data of depth below sea level demonstrated in *Figs.* 2 to *5* the depth of occurrence below the surface of all species can be obtained.

THE LOWER PANNONIAN

It transgressively overlies the emerging block of the basement resp. locally the Miocene. Its thickness is 500 to 1300 metres. In general it is divided into four lithologically different horizons among which faunistical differences also exist *(Fig. 1)*. From down to upwards these are as follows: 1. gravelly sandstone — conglomerate; 2. lime marl; 3. clay marl; and 4. sandstony sequence. In several places one or two of the initiating members may be absent. In these cases the Lower Pannonian begins directly with lime marl or clay marl.

The fauna of the Lower Pannonian consists mainly of benthonic elements, the nekton is represented by fish remnants. Thecamoeba are represented by three Silicoplacentina, Lamellibranchiata by twenty (out of them 14 Limnocardium and 5

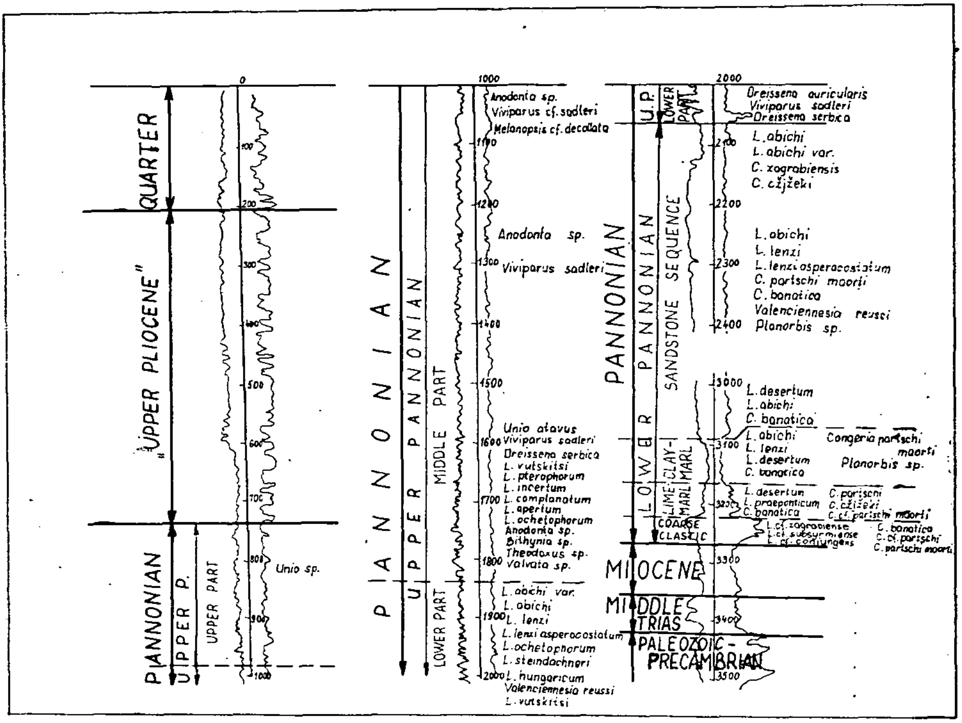


Fig. 1. Typical profile of the Algyő area. Classification and theoretical position of the important species of the Pannonian. — *Legend:* L. = Limnocardium; C. = Congeria; P. = Pannonian; U. P. = Upper Pannonian.

Congeria regarding their genera), Gastropoda by four and Ostracoda by three species. In the coarse starting strata sometimes mollusc shells also remain and numerous stone prints are also found. In the other part of the substage, however, almost only prints are found and 95 per cent of them is connected with the clay marl intercalations.

1. The coarse-clastic sequence overlies transgressively the basement. Its average thickness is 30 to 40 m, maximal thickness is 79 m. It may wedge both in high and in deep position. It consists of gravelly sandstone of changing grain size as well as of conglomerate containing quartz and metamorphite pebbles. The lowest part is the coarsest, upwards it becomes gradually finer. By means of fine-stratigraphic methods the sequence can be divided into subrhythms.

Its fauna is poorish and poorly preserved, in most cases it is restricted only to genus or species which can be determined only by cf. *(Figs. 2* and *3).* The fauna elements derive from a depth of 2380 to 2450 m below sea level and are assigned mostly to the genera Limnocardium and Congeria. Each species are usually restricted only to one or two bores, thus the dominancy conditions cannot be evaluated.

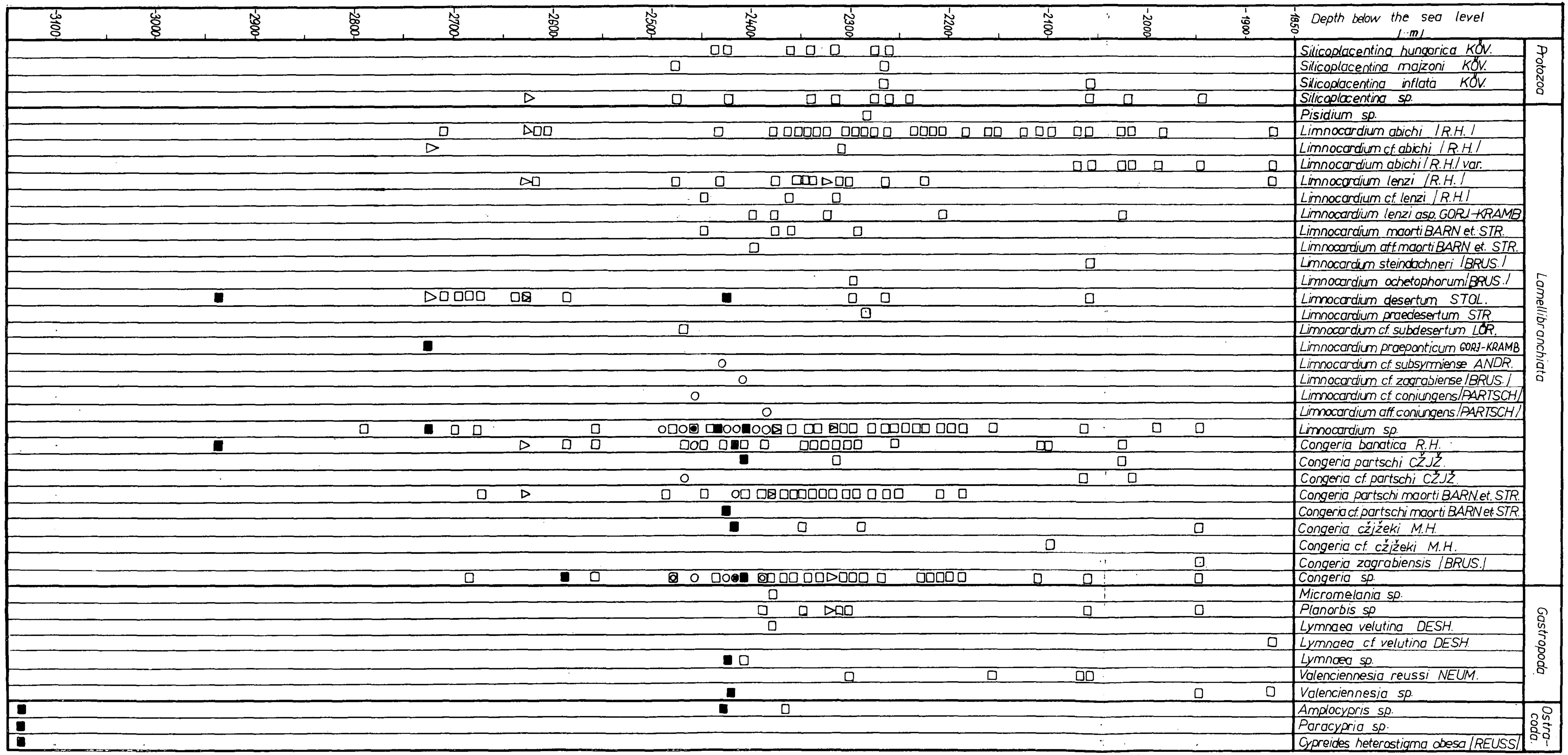


Fig. 2. Occurrence of the Lower Pannonian species of the Algyő area as a function of depth. —
Legend: ○ coarse clastic; ■ lime-marl; △ clay-marl; □ sandstony — sequence
asp. = asperocostatum

2. The coarse clastics resp. where this is absent the old basement are overlain by brownish-grey, in deeper positions by dark-coloured and brittle marl and lime marl in a thickness of 20 to 30 metres in average. Its formation relates to deeper-water reduction environment. It may wedge both in high and in deep positions.

Sequence	Species	Protozoa				Lamellibranchiata																													Gastropoda							Ostracoda		
		Silicoplacentina hungarica KÖV.	Silicoplacentina majzoni KÖV.	Silicoplacentina inflata KÖV.	Silicoplacentina sp.	Pisidium sp.	Limnocardium abichi (R.H.)	Limnocardium cf. abichi (R.M.)	Limnocardium abichi (R.H.) var.	Limnocardium lenzi (R.H.)	Limnocardium cf. lenzi (R.H.)	Limnocardium lenzi asp. GORJ.KRAMB.	Limnocardium maorti BARN.et STR.	Limnocardium aff. maorti BARN.et STR.	Limnocardium steindachneri (BRUS.)	Limnocardium ochetophorum (BRUS.)	Limnocardium desertum STOL.	Limnocardium praedesertum STR.	Limnocardium cf. subdesertum LÖR.	Limnocardium praeponticum GORJ.-KRAMB.	Limnocardium cf. subsyrmiense ANDR.	Limnocardium cf. zagrabiense (BRUS.)	Limnocardium cf. conjungens (PARTSCH.)	Limnocardium aff. conjungens (PARTSCH.)	Limnocardium sp.	Congeria banatica R.H.	Congeria partschi CŽJŽ.	Congeria cf. partschi CŽJŽ.	Congeria partschi maorti BARN.et STR.	Congeria cf. partschi maorti BARN.et STR.	Congeria čžjžeki M.H.	Congeria cf. čžjžeki M.H.	Congeria zagrabiensis (BRUS.)	Congeria sp.	Micromelania sp.	Planorbis sp.	Lymnaea velutina DESH.	Lymnaea cf. velutina DESH.	Lymnaea sp.	Valenciennesia reussi NEUM.	Valenciennesia sp.	Amplocypris sp.	Paracypria sp.	Cypreides heterostigma obesa (REUSS)
4	N. b.	7	2	2	8	1	29	1	7	12	3	5	3	1	1	1	6	1	1	–	–	–	–	–	33	17	2	2	22	–	3	1	1	32	1	6	1	1	1	4	2	1	–	–
	P. c.	7	2	2	10	1	47	1	8	18	3	5	4	1	1	1	11	1	1	–	–	–	–	–	81	23	2	2	27	–	3	1	1	59	1	7	1	1	1	4	2	1	–	–
3	N. b.	–	–	–	1	–	1	1	–	2	–	–	–	–	–	–	2	–	–	–	–	–	–	–	3	1	–	–	2	–	–	–	–	2	–	1	–	–	–	–	–	–	–	–
	P. c.	–	–	–	1	–	1	1	–	2	–	–	–	–	–	–	2	–	–	–	–	–	–	–	3	1	–	–	2	–	–	–	–	2	–	1	–	–	–	–	–	–	–	–
2	N. b.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	1	–	–	–	–	3	4	1	–	–	1	1	–	–	5	–	–	–	–	1	–	1	2	1	1
	P. c.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	1	–	–	–	–	3	4	1	–	–	1	1	–	–	9	–	–	–	–	1	–	1	2	1	1
1	N. b.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1	1	11	1	–	1	1	–	–	–	–	6	–	–	–	–	–	–	–	–	–	–
	P. c.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1	1	15	3	–	1	1	–	–	–	–	12	–	–	–	–	–	–	–	–	–	–

1 Coarse clastic 2 Lime-marl 3 Clay-marl 4 Sandstone sequence

Fig. 3. Occurrence of the Lower Pannonian species of the Algyő area according to the bores and number of pieces.
Legend: N. b. = number of bores;
P. c. = number of pieces;
asp. = asperocostatum

Its fauna is somewhat richer than that of the previous sequence. The genera Limnocardium and Congeria are predominant but gastropods and ostracods also occur. The marginal, i. e. deeper bores (deeper than 2720 m below the sea level) are characterized by *Limnocardium desertum* STOL. or by *Congeria banatica* R. H. In the bore Algyő—18 the core between 2936 and 2940 metres contained the two species together. In the lime marl of 4 m of the core between 2724 and 2742 metres of the neighbouring Algyő—8 bore *Limnocardium praeponticum* GORJ.-KRAMB. and *Limnocardium sp.* were determined. Thus, the lime marl of these two bores can be roughly correlated with the upper part of the preaponticum-horizon recorded by Á. JÁMBOR and M. KORPÁS-HÓDI [1971] in the Lajoskomárom—1 bore of Transdanubia. In the strata of central, *i. e.* higher position (between 2400 and 2720 m below sea level) also the *Limnocardium desertum* STOL. and the *Congeria banatica* R. H. are most frequent, but in addition to them the species *Congeria partschi* CŽJŽ., *Congeria cf. partschi maorti* BARN et STR., *Congeria cžjžeki* M. H., *Valenciannesia sp.* and *Lymnaea sp.* are also found in each bores and are represented by one-one specimen.

3. As against the two previous sequences, the clay marl sequence is of regional extension. Its average thickness is 40 to 50 metres. In certain cases this amounts to only 10 to 20 and in a few places to more than 100 metres. In several places (*i. e.* in top-position) it directly overlies the basement. It consists primarily of dark-grey clay marl and subordinately of fine aleurite. It is nearly completely sand-free. It may contain sporadically lime marl strips resp. quartz and metamorphite pebbles at the edges of the structure. In such case the lime marl sequence resp. the coarse-clastic sequence can be considered to be heteropic facies.

Due to the small number of core samples only insufficient data known on the fauna (*Figs. 2* and *3*). The species derive from the depth interval of 2320 to 2720 metres below sea level. The *Limnocardium desertum* STOL. and the *Congeria banatica* R. H. spreading from the lower sequence across to this horizon but the *Limnocardium abichi* (.R H.) and the *Limnocardium lenzi* (R. H.) being of increasing importance also occur. The Silicoplacentina are also found. The gastropods are represented by the *Planorbis sp.* Similarly to the lime marl, probably the *Congeria banatica* R. H. and the *Limnocardium desertum* STOL. are most frequent also in this horizon.

4. The thickness of the sansdtony sequence amounts to 500 to 1000 metres. In higher position it is thinner, while in deeper one it is thicker. It consists of the monotonous rhythmic alternation of grey aleurite, dark-grey clay marl light-grey fine resp. medium-fine sandstone. The sandstones may be either thin- and thick-bedded or lamellar. They are mostly fine-grained, subordinately very fine-grained, the medium-grained varieties occur sporadically. Gravel substance is absolutely absent. The rhythms are thicker down (50 to 100 m) and thinner upwards (20 to 30 m). Their number is 7 to 8, max. 22. The proportion of the sandstone strata of the sequence estimated on the basis of carottage profiles is about 15 per cent.

The pelitic intercalations of the sequence is characterized by abundant fauna regarding the numbers of both the species and individuals. The species were found in the depth interval between 1870 and 2790 m below sea level *(Fig. 2)*. On faunistic bases further three parts can be distinguished (which cannot be performed from the petrological point of view): *a)* a lower horizon poorest in fauna (below the 2420 m level below the sea level);*b)* a medium section of most abundant fauna (in the depth interval between 2120 and 2420 m below sea level); *c)* an upper part of medium-rich fauna (above the depth level of 2120 m below sea level). (It is to be noted here that in the fauna abundance of the middle section the greatest number of core samples is of primordial role.)

The fauna of the lower part consists solely of Limnocardium and Congeria. The *Limnocardium desertum* STOL. is the most frequent and wide-spread species. The abundance of this species of long generation seems to fall into this period. In addition to it *Limnocardium abichi* (R. H.) and *Congeria banatica* R. H. are important, further *Limnocardium lenzi* (R. H.) and *Congeria partschi maorti* BARN. et STR. are also found.

The middle part is of more variegated and abundant fauna. The significance of the genus Silicoplacentina increases. Out of their three species the *Silicoplacentina hungarica* KŐV. is most frequent. Out of the molluscs the species *Limnocardium abichi* (R. H.) is extraordinarily dominant (and at the same time abundant) which is frequent mainly above the depth of 2320 m below the sea level. As against the statement of M. SZÉLES [1971] not the *Limnocardium lenzi* (R. H.) but the species *Congeria partschi maorti* BARN. et STR. is subdominant. (The difference may be caused by the fact that she assigns the "transitional zone" between the Lower and Upper Pannonian — the lower part of which is characterized by relatively frequency of the *Limnocardium lenzi* (R. H.) — to the Lower Pannonian). The third most frequent species is the *Congeria banatica* R. H. and this is followed by the *Limnocardium lenzi* (R. H.), see *Fig. 6.* (All these dominance conditions are valid of the whole sandstony sequence.) The *Congeria partschi* ČŽJŽ. and the *Congeria cžjžeki* M. H. are rare, the *Limnocardium lenzi asperocostatum* GORJ.-KRAMB. and the *Limnocardium ochetophorum* (BRUS.) also occur. Out of the gastropods the *Valenciannesia reussi* NEUM. and the *Planorbis sp.* are most significant. Ostracods are represented only by the *Amplocypris sp.*

The fauna of the upper part shows certain transition towards the Upper Pannonian. The *Limnocardium abichi* (R. H.) is dominant, the *Congeria banatica* R. H. is frequent, the *Limnocardium abichi* (R. H.) *var.* and the *Limnocardium steindachneri* (BRUS.) also occur. The *Limnocardium desertum* STOL., the *Limnocardium lenzi* (R. H.), the *Limnocardium lenzi asperocostatum* GORJ.-KRAMB., the *Congeria partschi* ČŽJŽ., the *Congeria cžjžeki* M. H. and the *Congeria zagrabiensis* (BRUS.) can be found in a few occurrences *(Figs. 2, 3* and *6)*.

The fauna has been discussed while following the lithofaciological units. Biostratigraphically, however, the following three horizons can be distinguished:

1. The coarse clastics, the lime marls, the clay marl sequence of the deep-seated areas as well as the lower thick-bedded part of the sandstony sequence are assigned to the lower part (roughly below the depth level of 2420 m below sea level). Its littoral fauna is represented by a few and poorly preserved species *(Figs. 1* and *2)*. Its intra-basin formation is characterized by *Congeria banatica* R. H. in the lower part and by *Limnocardium desertum* STOL. in the upper part though the former is continuously significant. In the lowermost horizon the *Limnocardium praeponticum* GORJ.-KRAMB is also found. After the deposition of the lime marl strata the *Limnocardium abichi* (R. H.) and the *Limnocardium lenzi* (R. H.) occur in the clay marl sequence and become of ever growing importance from down to upwards.
2. The part of the sandstony sequence lying between 2120 and 2420 m below sea level is assigned to the middle part and which can be characterized with decreasing frequency by the *Limnocardium abichi* (R. H.), *Congeria partschi maorti* BARN. et STR., *Congeria banatica* R. H. and *Limnocardium lenzi* (R. H.) This sequence is most abundant fauna composition *(Figs. 1* and *2)*.
3. The upper part of the sandstony sequence of about 200 m thickness extending up to the boundary of the Lower and Upper Pannonian is assigned to the upper part. In this sequence also the *Limnocardium abichi* (R. H.) is dominant but its aberrant variety, the *Limnocardium abichi* (R. H.) *var.* also occurs. Consequently, certain transition is shown towards the Upper Pannonian. On the basis of the relatively great number of common species (*i. e. Limnocardium steindachneri* (BRUS.), *Limnocardium lenzi* (R. H.), *Congeria zagrabiensis* (BRUS.) *Congeria cžjžeki* M. H. this horizon can be roughly correlated with the upper marginal horizon of Á. JÁMBOR, M. KORPÁS-HÓDI, [1971].

THE UPPER PANNONIAN

Its thickness is 1200 to 1400 m. It overlies the Lower Pannonian by angular discordance. Both the lower and the upper boundaries of it can be drawn only lithologically. Its lower boundary is marked by strong sandification shown also by the carottage profiles and this is for the most part accompanied by significant change of fauna. Its upper boundary is marked at the floor of the first thick-bedded and high-resistant sand layer lying between 650 and 750 m below sea level. The sequence extending from this horizon up the Quaternary is not assigned to the Upper Pannonian but this will be separately discussed under the term "Upper Pliocene" *(Fig. 1)*.

The Upper Pannonian sequence is of regressive character. It is characterized by the sudden increase of sandstones up to 40 per cent in average (value estimated on the basis of profiles). Its petrological picture is much more variegated than that of the Lower Pannonian. The three main rock types are also the sandstone, aleurite and clay marl (though the latter is considerably restricted), the sandstone lenses of 20 to 50 cm, max. 1 to 2 m thickness and of hard carbonate cementing material as well as the lime-marl, woody brown-coal and coaly clay intercalations are rather frequent. In addition to this quartz pebbles occur though sporadically. All these fairly reflect the changed sedimentary environments. The thickness of the unstratified parts of the same material is 5 to 10 m at least and only above 1200 to 1300 m occur the thicker (20 to 30 m) homogeneous strata.

Its fauna is much more abundant than that of the Lower Pannonian *(Figs. 4* and *5)*. The number of species and individuals is suddenly increasing. The fauna of the substage consists of 4 Thecamoeba, 40 Lamellibranchiata (out of them 27 is assigned to the genus Limnocardium), 14 Gastropoda and 17 Ostracoda species *(Fig. 5)*. Most of them derive from the best discovered lower part of 300 m; above this horizon only several data are available. Since the boundary between the lower and middle part of the substage is not always sharp, in case of demonstrating the fauna the separation according to horizons was neglected *(Figs. 4* and *5)*. In addition to the clay marl, the enclosing rock is often sandstone or coaly clay.

The Hungarian Upper Pannonian sequence including the "Upper Pliocene" separated by us was divided into three horizons by F. Bartha [1971*a*, *b*, 1974, 1975]. Mainly M. Széles [1962, 1966, 1968*c*, 1971] dealt with the intra-basin Upper Pannonian fauna of the Great Plain. She stated the mixing of the Lower and Upper Pannonian fauna in the lower 200—300 metres of the Upper Pannonian of F. Bartha [1971*a*, *b*, 1974, 1975] determined in the Algyő area and she assigned this part as a "transitional zone" to the Lower Pannonian.

On the basis of partly the fauna (in the lower section) and partly the lithology, the Upper Pannonian of Algyő is divided by ourselves as follows:

1. Lower sequence. This extends from lithologically drawn lower boundary (1900—2120 m below sea level) up to the faunistically drawn upper boundary (about 1720—1830 m below sea level). Roughly the "transitional zone" of M. Széles is included within this zone. Its varied rock types show the fundamental changes of the sedimentary environments. Thinner (max. 50 cm thick) woody brown-coal and coaly clay strata are present already from the lowermost part of the horizon. Upwards, around the boundary of the middle horizon no sharp lithological change can be observed, only the increase of small extent of the number of woody brown-coal and coaly clay strata being frequent in the whole sequence can be observed in the core samples. Further evidences of shallowing are the frequently observable coaly plant fragments in the aleurites and sandstones of the core samples, the coal bands of several millimetres and locally the traces of drying. In the lower member the filling up was of considerable measure so in addition to the shallow lacustrine environment marshy and bog environments also occur. Smaller islands might exist but continuous greater lands could not be found. The origin of the quartz pebbles occuring sporadically in the whole sequence is debated. The listed sedimentary environments alternate spatially beside one another and temporally subsequently forming thus a jagged sequence. According to M. Mucsi [1973] and M. Mucsi, I.

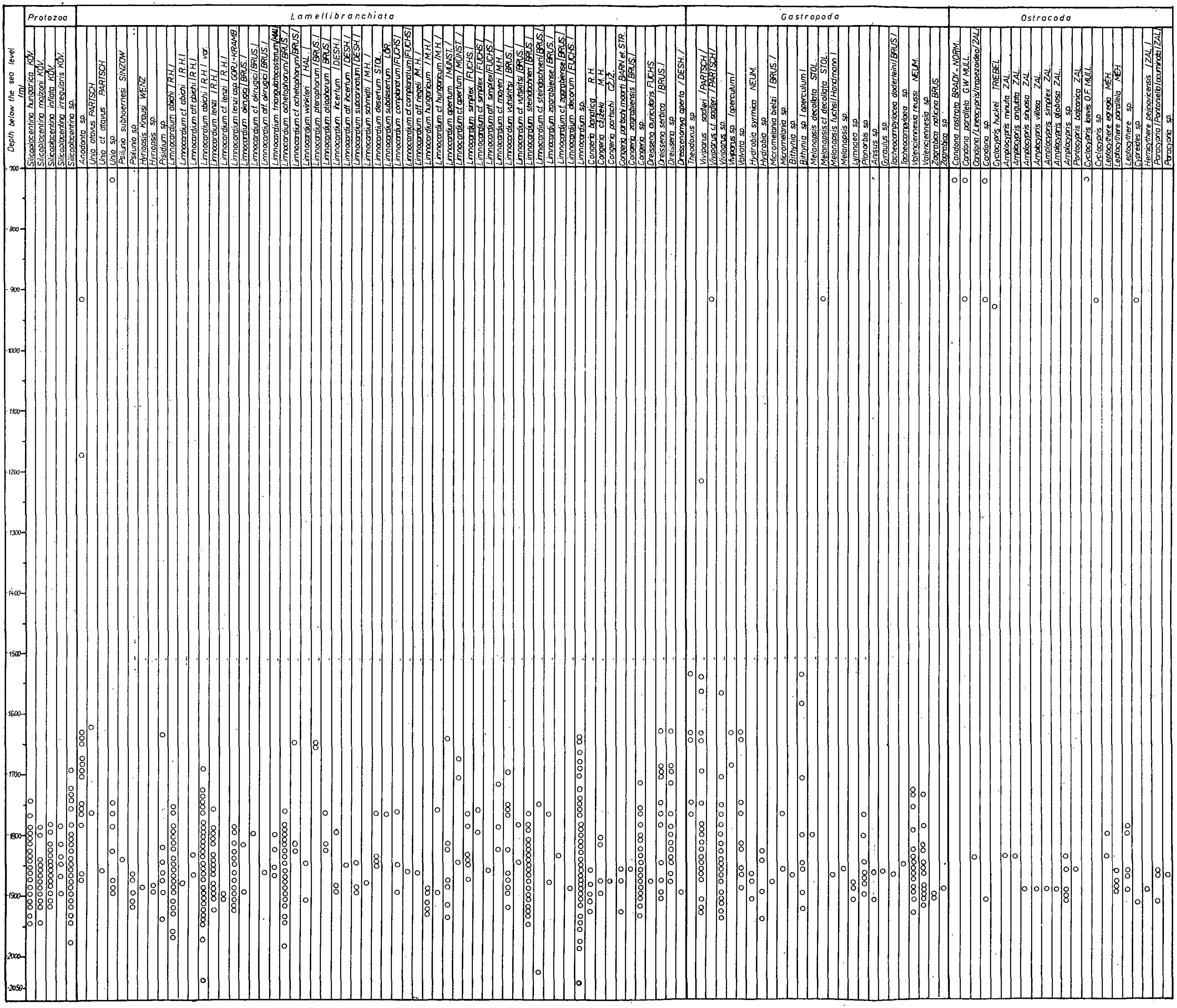


Fig. 4. Occurrence of the Upper Pannonian species of the Algyő area as a function of depth.
Legend: asp. = asperocostatum

	Species	N.b	Pc.
Protozoa	Silicoplacentina hungarica KŐV.	41	60
	Silicoplacentina majzoni KŐV.	15	17
	Silicoplacentina inflata KŐV.	18	20
	Silicoplacentina irregularis KŐV.	5	7
	Silicoplacentina sp.	51	88
Lamellibranchiata	Anodonta sp.	17	20
	Unio atavus PARTSCH	2	2
	Unio cf. atavus PARTSCH	1	1
	Unio sp.	7	8
	Psilunio subhoernesi SINZOW	1	1
	Psilunio sp.	5	7
	Hyriopsis Krausi WENZ	2	2
	Hyriopsis sp.	2	2
	Pisidium sp.	7	7
	Limnocardium abichi (RH.)	30	43
	Limnocardium cf. abichi (R.H.)	2	2
	Limnocardium aff. abichi (R.H.)	1	1
	Limnocardium abichi (R.H.) var.	202	484
	Limnocardium lenzi (R.H.)	14	16
	Limnocardium cf. lenzi (R.H.)	1	1
	Limnocardium lenzi asp. GORJ-KRAMB	42	51
	Limnocardium okrugici (BRUS.)	2	2
	Limnocardium cf. okrugici (BRUS.)	1	1
	Limnocardium aff. okrugici (BRUS.)	1	1
	Limnocardium triangulatocostatum (HAL.)	4	4
	Limnocardium ochetophorum (BRUS.)	77	98
	Limnocardium cf. ochetophorum (BRUS.)	3	3
	Limnocardium winkleri (HAL.)	2	2
	Limnocardium pterophorum (BRUS.)	1	1
	Limnocardium otiophorum (BRUS.)	1	3
	Limnocardium incertum (DESH.)	3	3
	Limnocardium aff. incertum (DESH.)	1	1
	Limnocardium subcarinatum (DESH.)	3	3
	Limnocardium schmidti (M.H.)	1	3
	Limnocardium desertum STOL.	5	5
	Limnocardium subdesertum LŐR.	1	1
	Limnocardium complanatum (FUCHS.)	1	3
	Limnocardium cf. complanatum (FUCHS.)	1	1
	Limnocardium aff. riegeli (M.H.)	1	1
	Limnocardium hungaricum (M.H.)	5	5
	Limnocardium cf. hungaricum (M.H.)	2	2
	Limnocardium apertum (MÜNST.)	6	6
	Limnocardium cf. apertum (MÜNST.)	3	3
	Limnocardium simplex (FUCHS)	6	7
	Limnocardium cf. simplex (FUCHS.)	2	2
	Limnocardium aff. simplex (FUCHS.)	1	1
	Limnocardium cf. mayeri (M.H.)	3	3
	Limnocardium vutskitsi (BRUS.)	11	14
	Limnocardium cf. vutskitsi (BRUS.)	2	2
	Limnocardium steindachneri (BRUS.)	50	58
	Limnocardium cf. steindachneri (BRUS.)	2	2
	Limnocardium zagrabiense (BRUS.)	2	2
	Limnocardium cf. zagrabiense (BRUS.)	1	1
	Limnocardium decorum (FUCHS.)	1	1
	Limnocardium cristagalli (ROTH)	1	1
	Limnocardium cf. prionophorum (BRUS.)	1	1
	Limnocardium sp.	198	416
	Congeria banatica R.H.	5	5
	Congeria czjzeki M.H.	4	6
	Congeria partschi CZJŽ.	2	2
	Congeria partschi maortiBARNet. STR.	4	4
	Congeria zagrabiensis BRUS.	1	1
	Congeria sp.	37	60
	Dreissena auricularis FUCHS.	1	1
	Dreissena serbica BRUS.	12	22
	Dreissena sp.	14	17
	Dreissenomya aperta (DESH.)	1	1

	Species	N.b	Pc.
Gastropoda	Theodoxus sp.	4	6
	Viviparus sadleri (PARTSCH.)	21	28
	Viviparus cf. sadleri (PARTSCH.)	1	1
	Viviparus sp.	38	47
	Viviparus sp. (operculum)	1	2
	Valvata sp.	9	10
	Hydrobia syrmica NEUM.	3	3
	Hydrobia sp.	4	4
	Micromelania bielzi (BRUS.)	1	1
	Micromelania sp.	2	2
	Bithynia sp.	1	1
	Bithynia sp. (operculum)	9	11
	Melanopsis decollata STOL.	1	1
	Melanopsis cf. decollata STOL.	1	1
	Melanopsis fuchsi (HANDMANN.)	1	1
	Melanopsis sp.	1	1
	Lymnaea sp.	6	6
	Planorbis sp.	9	9
	Anisus sp.	2	2
	Gyraulus sp.	1	1
	Tacheocampylaea doderleini (BRUS.)	1	1
	Tacheocampylaea sp.	1	1
	Valenciennesia reussi NEUM.	28	33
	Valenciennesia sp.	15	16
	Zagrabica naticina BRUS.	2	2
	Zagrabica sp.	1	1
Ostracoda	Candona rostrata BRADY – NORM.	1	1
	Candona parallela G.W. MÜLL.	1	2
	Candona (Lineocypris) trapezoidea (ZAL.)	1	1
	Candona sp.	2	3
	Amplocypris minuta ZAL.	1	1
	Amplocypris angulata ZAL.	1	1
	Amplocypris sinuosa ZAL.	1	1
	Amplocypris villosa ZAL.	1	1
	Amplocypris simplex ZAL.	1	1
	Amplocypris globosa ZAL.	1	1
	Amplocypris sp.	5	5
	Pontocypris balcanica ZAL.	1	1
	Cyclocypris laevis O.F. MÜLL.	1	1
	Cyclocypris huckei TRIEBEL	1	1
	Cyclocypris sp.	1	1
	Leptocythere egregia MÉH.	2	2
	Leptocythere parallela MÉH.	4	4
	Leptocythere sp.	10	10
	Cypreides sp.	2	2
	Hemicythere pejnovicensis (ZAL.)	1	1
	Paracypria (Pontoniella) acuminata (ZAL.)	4	4
	Paracypria sp.	1	1

Fig. 5. Occurrence of the Upper Pannonian species of the Algyő area according to the bores and number of pieces.
Legend: see Fig. 3.

RÉVÉSZ [1975] the upper two-third of the sequence is characterized by the delta sedimentation and by the related environments.

Regarding the fauna the great aberrant varieties of the *Limnocardium abichi* (R. H.) and *Limnocardium lenzi* (R. H.) spreading from the Lower Pannonian are most characteristic of this sequence. The varieties of the former species were described by M. SZÉLES [1962] as *Limnocardium abichi* (R. H.) *var.* which is extremely dominant and at the same time abundant in the whole lower sequence. Further significant species spreading across to the Upper Pannonian are the following: the subdominant *Limnocardium ochetophorum* (BRUS.), the third most frequent *Limnocardium steindachneri* (BRUS.), as well as the *Valenciennesia reussi* NEUM., *Limnocardium desertum* STOL., *Congeria banatica* R. H., *Congeria cžjžeki* PARTSCH, *Congeria partschi maorti* BARN et STR. *(Fig. 6)*. Species becoming more significant only in the upper parts of the Upper Pannonian also occur. Out of them the *Viviparus sadleri* (PARTSCH), the *Psilunio sp.* and the *Hydrobia sp.* appear already at the bottom of the horizon, the *Limnocardium vutskitsi* (BRUS.), the Dreissena and Bithynia in the lower third, while the Hyriopsis, Anodonta, Tacheocampylaea and Unio genera occur first somewhat later. The change of the lithofacies, however, does not correlate always with the appearance of new species. In two cases a fauna of exactly Upper Pannonian character was found below the Lower — Upper Pannonian boundary determined by electric profiles. Between 1915 and 1930 m below sea level of the bore Algyő 363. *Viviparus sadleri* (PARTSCH) and *Psilunio sp.* were found together with *Limnocardium steindachneri* (BRUS.) and *Limnocardium hungaricum* (M. H.). Between 1919.5 and 1937.5 m below sea level in the bore of Algyő 392. the fauna assemblage consists of *Viviparus sp., Pisidium sp., Limnocardium steindachneri* (BRUS.) and *Hydrobia sp.* These occurrences were of course assigned to the Upper Pannonian.

The upper boundary of the lower sequence cannot be always exactly determined. This falls in general between 1720 and 1770 m below sea level, sometimes it lies, however, somewhat deeper. Faunistically, the upper boundary is marked by the uppermost occurrences of the *Limnocardium abichi* (R. H.), *Limnocardium lenzi* (R. H.), *Limnocardium lenzi asperocostatum* GORJ.-KRAMB., *Limnocardium desertum* STOL., *Limnocardium steindachneri* (BRUS.) and *Valenciennesia reussi* NEUM., resp- by the increased frequency of the *Anodonta sp., Dreissena, Vivipara* and *Limnocardium vutskitsi* (BRUS.).

The species of this sequence are especially facies indicators. In most of the cases the "younger" Vivipara, Bithynia, Anodonta, Psilunio, Hydrobia, Hyriopsis, Tacheocampylaea and the *Limnocardium vutskitsi* (BRUS.) occur in coaly clay intercalations. If occasionally the enclosing rock is of other type the sediments of the marshy environment can always be found in their close neighbourhood. The fauna assemblage of the sandstone called Algyő—2 fairly demonstrates this phenomenon containing coaly strata in the nortwestern part of the area (lying at about the third of the lower sequence). In the lower two-third of this the *Limnocardium abichi* (R. H.) of "older type" is found in a dominancy of 90 per cent. From the coaly clay deposited in the upper third of the sandstone the following fauna of mostly "younger type" was found: *Anodonta sp. Psilunio sp., Pisidium sp., Dreissena serbica* (BRUS.), *Hydrobia syrmica* (BRUS.), *Hyriopsis sp., Bithynia sp., Tacheocampylaea doderleini* (BRUS.) *Planorbis sp., Viviparus sadleri* (PARTSCH), *Viviparus sp., Limnocardium ochetophorum* (BRUS.), *Limnocardium vutskitsi* (BRUS.), *Limnocardium sp.* Above it the fauna elements considered to be "older" appear again indicating the return of lacustrine environment. Consequently, the environment and together with it the fauna changes cyclically.

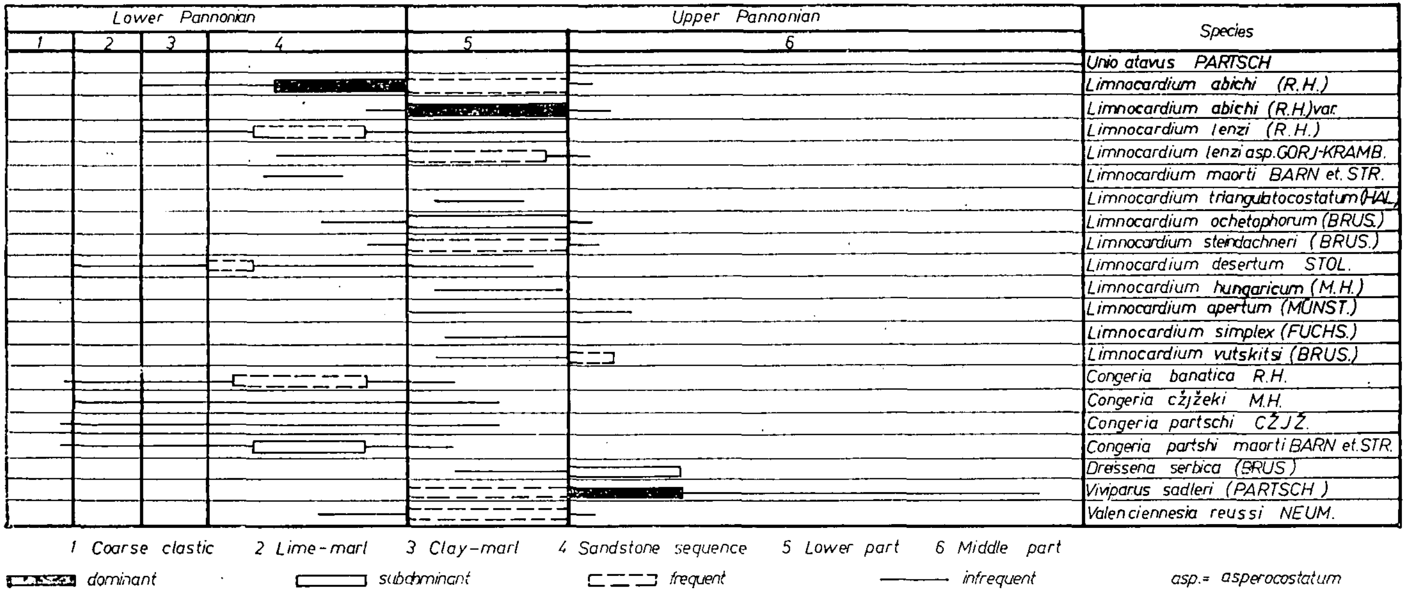


Fig. 6. Generation of the most important Pannonian species of the Algyő area.

In many cases the Dreissena are found in sandy biotope. In numerous bores of the area (e. g. Algyő—3, 11, 33, 41, 183 and 242), between the depth interval of 1760 and 1900 metres below sea level thin, non horizon-keeping, hard aleuritic-sand-stony Lumasella lenses of carbonate cementing material are found in which mostly rare eastern species occur. (e. g. *Limnocardium incertum* (DESH.), *subcarinatum* (DESH.), *complanatum* (FUCHS), *Hyriopsis krausi* WENZ.). The appearance of the *Viviparus sadleri* (PARTSCH) and *Limnocarduim vutskitsi* (BRUS.) considered to be also of eastern origin is explained by F. BARTHA [1971*a*, *b*, 1974, 1975] by the short opening of the Porta Ferrea. As against the major part of our occurrences in Algyő both species occur already at the bottom of the Upper Pannonian, frequently in one occurrence in the same core sample. In the area in question the number of Viviparus occurrences amounts to 36. The *Limnocardium vutskitsi* (BRUS.) is known from six bores till now. In Algyő out of the fossils indicating the lower member (similarly to Ferencszállás lying in the direct southeastern neighbourhood) the *Dreissena auricularis* (FUCHS) occurred only in one core sample; cores, however, containing *Congeria rhomboidea* M. H. and *Congeria ungulacaprae* MÜNST. were not drilled yet.

The classification of age of the sequence is debated. The boundary between the Lower and Upper Pannonian is drawn by M. SZÉLES [1966, 1968*a*, 1968*c*, 1971] and J. KŐVÁRY [1973] on faunistical bases, by É. SZABÓ.-KILÉNYI and GY. SZÉNÁS [1971] on the basis of seismic profiles at the top of the sequence. On the contrary, mostly on lithological bases L. VÖLGYI [1965], L. KŐRÖSSY [1968, 1971], L. VÖLGYI, K. BALLA, S. SUBA, I. CSALAGOVITS [1970], F. BARTHA [1971*a*, 1974, 1975] and M. MUCSI, I. RÉVÉSZ [1975] put it to the bottom of the sequence. The assignment of the seqence in question is evidenced by the following reasons:

a) On the basis of the geophysical profiles and core samples the percentual ratio of the sand strata suddenly increases at the bottom of the sequence.
b) In the sequence varied sedimentary environments are found. Most important is the presence of the intercalations of woody brown-coal and coaly clay strata since the beginning of the sequence.
c) The carbonate content is somewhat lower than in the Lower Pannonian.
d) As against the Lower Pannonian in the lower sequence (but also in the lower two-third of of the middle sequence) only thinner (max. 5 to 10 metres)

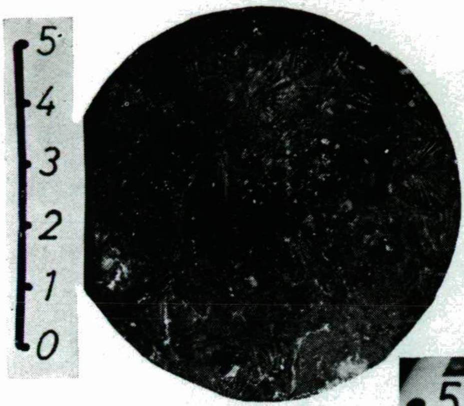
EXPLANATION OF PLATES

PLATE I

1. Clay marl containing *Congeria banatica* R. H. and *Limnocardium abichi* (R. H.). Lower Pannonian. — Bore Algyő 8. 2683—2687 m.
2. *Limnocardium steindachneri* (BRUS.), *Limnocardium sp.* in fine-grained aleurite. Upper Pannonian. — Bore Algyő 290. 1960—1965 m,
3. *Viviparus sadleri* (PARTSCH) in coaly clay. Upper Pannonian. — Bore Algyő 360. 1995—2007 m

PLATE II

1. Clay marl containing *Viviparsu sadleri* (PARTSCH). Upper Pannonian. — Bore Algyő 279. 1870—1882 m.
2. *Limnocardium abichi* (R. H.) and *Limnocardium abichi* (R. H.) *var.* in clay marl. Upper Pannonian. — Bore Algyő 399. 1956—1973 m.
3. *Dreissena sp.*, *Congeria partschi maorti* BARN. et STR. and *Congeria sp.* in limy aleurit. — Bore Algyő 3. 1966,5—1984,5 m.



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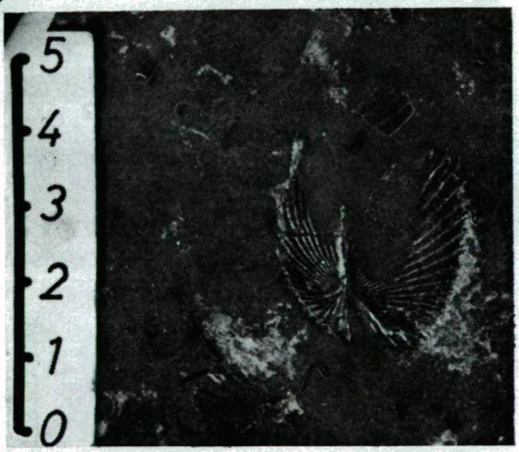

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homogeneous strata are found. This indicates the considerable change of kinetic energy of the deposition medium.

e) On the basis of grain size distribution investigations strong fluctuation of sorting begins in the lower sequence.

f) The composition of the fauna makes also evidences to assign the sequence into the Upper Pannonian. Nevertheless, it is true that the brackish species of the Lower Pannonian are predominant, but in the lower part of the sequence (sometimes in its lowermost part) the eastern Caspian brackish species appear, moreover these are relatively frequent. (Regarding the frequency the *Viviparus sadleri* (PARTSCH) is the seventh among the species.) The great aberrant fossils of the *Limnocardium abichi* (R. H.) and *Limnocardium abichi* (R. H.) indicate undoubtedly the fundamental change of the sedimentary environments.

g) The data of salt content of the strata carried out in the hydrocarbon prospecting bores (referring to NaCl according to VOLHARD) show that the sediments of the lower part bear freshwater. All the results lie below 0.5 g/l, moreover, fall between 0.05 and 0.11 g/l. On the contrary, in the Lower Pannonian just somewhat below the Lower — Upper Pannonian boundary values greater by an order of magnitude, *i. e.* 1 to 3 g/l are found.

2. Middle sequence. Its upper boundary can be drawn between 900 and 1100 metres below sea level by means of the upward lack of the frequently and continuously occurring thicker woody brown-coal lenses being predominant in the depth cited *(Fig. 1)*. (Higher up there are also sporadically lignite strata but these are thin.) The marshy strata disappear by certain time difference in different bores, thus the boundaries marked by means of them can be only hardly correlated.

This means that the Pannonian inland lake was decomposed into parts just at the beginning of the middle sequence, as a result of the high-grade filling up, the shallow lacustrine environment lost its predominance and forwarding upwards the marshy strata become gradually predominant. While on the basis of the core samples in the lower sequence only woody brown-coal strata of 20 to 50 cm thickness can be demonstrated, from the bottom of the middle sequence those thicker than one metre also occur. The sediments are loose, in general. The clay marls and aleurites are of lighter colour, greyish-green, occasionally yellowish shade of colour, and are often of ochre spots and lime concretions. Unfortunately, on the basis of cores only the lower section of 100 to 150 metres are better known, on the upper parts in addition to the few cores the bore material and the electric profiles give some information. According to these upward from the detph of 1100 to 1200 m below sea level homogeneous strata of 20 to 30 m thickness are also found.

As a result of the incomplete core sampling the fauna of only the lower part of 100 to 150 m is known in detail. At the lower boundary drawn on faunistical bases the species characteristic of the lower section disappear and are replaced by "typical" Upper Pannonian forms.

Some individuals of the Silicoplacentina which can be determined only by genera occur already in the lower part of the sequence. Lamellibranchiata are represented by 16, Gastropoda by 6 species. Regarding the number of species the Limnocardium is predominant (11 species) but out of them only the *Limnocardium vutskitsi* (BRUS.) is frequent. It was found in seven bores up to 1690 metres below sea level. In addition to it only the *Limnocardium abichi* (R. H.) *var.* (uppermost occurrence between 1685 and 1703 m below sea level), the *Limnocardium ochetophorum* (BRUS.)

and the *Limnocardium apertum* (MÜNST.) are of greater significance. All the other species of Limnocardium were found only in one or two bores in one or two specimens *(Figs. 4* and *5)*.

The role of *Anodonta sp.* considerably increases (18 pieces at 15 occurrences). The lack of *Unio atavus* PARTSCH, *Unio sp.* and *Pisidium sp.* in the upper parts is caused probably by the incomplete core sampling. *Congeria sp.* were found up to 1720 m below sea level and are characterized by some individuals which can be determined only in generic level. The Dreissena of great importance are found up to 1620 m below sea level, mostly in sandstone lenses. *Dreissena serbica* (BRUS.) and *Dreissena sp.* were found in seven (17 specimen) resp. eight (9 specimen) bores. Out of the gastropods Vivipara are of greatest importance, these occur continuously up to 1540 m below sea level and only sporadically above this depth. Up to now these were found in 20 bores. The following fossils are worthy of mention: *Theodoxus sp., Bithynia sp., Valvata sp., Planorbis sp.* and *Melanopsis cf. decollata* STOL. (Their infrequent occurrence is caused by all means by rare core sampling.)

In the middle third of the sequence no faunabearing core drilling was performed, only in the upper third gives some information. In 1170 m of Algyő—1 *Anodonta sp.*, in 1220 m of Algyő—4 *Viviparus sadleri* (PARTSCH), in 920 m of Deszk—1 *Anodonta sp., Viviparus cf. sadleri* (Partsch) and *Melanopsis cf. decollata* STOL. were found (data of depth below sea level). The latter species indicate the uppermost part of the sequence.

3. The upper sequence lies between the depth interval of 900—1100 m below sea level up to the bottom of the thick-banked sand strata of high resistance occurring between 650 and 750 m below sea level *(Fig. 1)*. This boundary, however, may fluctuate laterally by 20 to 50 metres. The filling up had been of very high rate so that the Pannonian inland lake ceased and the fluvio-lacustrine sedimentation became predominant. The most important rocks are as follows: greenish-grey clay often of ochre spots and lime concretions, aleurite and light-grey sand. Rarely thin peat and coaly clay intercalations as well as smaller banks consisting of small-grained quartz pebbles are found. Only one core was drilled in this sequence. Between the depth interval of 715 and 721 m below sea level of the bore Deszk—1 *Unio sp.* Ostracoda were determined *(Fig. 4)*.

The correlation of the trisected Upper Pannonian of the Algyő area with the contemporaneous sediments of other intrabasin sequences and especially with those of the marginal areas is recently rather troublesome. According to the analogies of other intrabasin occurrences the lower sequence corresponds to the horizons characterized by Ungulacaprae and Subglobosa. In the middle sequence out of the species characteristic of the marginal parts of the basin the *Congeria balatonica* PARTSCH and the *Congeria triangularis* PARTSCH do not occur, instead of them the *Viviparus sadleri* (PARTSCH), the *Limnocardium vutskitsi* (Brus.) and the *Dreissena serbica* (BRUS.) are most frequent. The woody brown-coal and coaly clay strata are common also in Algyő, but occur in the whole lower sequence and by means of them the whole lower sequence and by means of them the separate "oscillation" period of F. BARTHA, [1971*a*, *b*, 1974, 1975] cannot be distinguished. His Upper Pannonian is wider in time than that of us since it includes our "Upper Pliocene", too, as the uppermost member of the substage. On the contrary, our uppermost member may correspond to the lower part of the upper sequence of the classification of the marginal parts quoted above.

SUMMARY

The exact classification of the intrabasin Pannonian sequences of great thickness as well as their correlation with the marginal areas are unsolved till now. This can be explained partly by the incomplete knowledge of the intrabasin areas caused by sparse core sampling, partly by facies differences. In different basin parts of the Pannonian inland lake petrologically different sediments were deposited simultaneously. The thickness of the sediments was determined first of all by the changing rate of the subsiding movements of the basement and of the areally changing filling up. Since the fauna followed the changes of lithofacies in general, the individual fauna assemblages appeared or extincted in different areas by certain time delay. Consequently, especially from the Upper Pannonian the fauna indicates rather environment than age. Consequently, considerable faunistical differences developed between the single basin parts and often the generations also differ. The picture given on the Algyő area can be only outlined and cannot be regarded complete.

I. 1. In most of the bores the Lower Pannonian substage has four lithofacies overlying each other and out of which the lower three may replace each other laterally. Thus, the different occurrences of the same lithofacies are by no means contemporaneous.

2. After the accumulati onof the transgressive basal conglomerate surrounding ring-likely the Algyő island, somewhat deeper marls and lime marls developed as a result of the relatively faster subsidence of the basement, which spread horizontally over the coarse clastic sequence. In this phase the subsidence is faster than the filling up.

3. The clay marl sequence is the first complex which is commonly widespread. The water table reached its greatest extension at that time. The rate of filling up falls behind the subsidence.

4. The sandstony sequence is the thickest and most explored strata series which consists of thicker strata in the lower and thinner rhythms in the upper part, in general. The lower part is characterized by slower subsidence and faster filling up while the upper part can be characterized by the nearly same rate of subsidence and filling up.

5. The Lower Pannonian of Algyő cannot be recently satisfactorily classified from the biostratigraphic point of view. Regarding only the fauna the stage seem to be trisected. Only a rough correlation is possible with formations of the marginal parts.

II. 1. The Upper Pannonian overlies the Lower Pannonian by angular discordance; its lower boundary can be marked lithologically (on the basis of electric profiles) just due to its more sandy composition.

2. From the beginning of the Upper Pannonian the filling up had been of considerable measure, so that in addition to the shallow lacustrine environments marshy and bog environments should also be taken into consideration. These follow one another spatially beside, temporally above each other.

3. Partly on faunistical and partly on lithological bases the Upper Pannonian has been divided into a lower, middle and upper sequence which, however, cannot be exactly correlated neither with other intrabasin, nor with other marginal formations.

4. The lower sequence is characterized by the predominance of the shallow lacustrine environment, though the role of marshy and bog environments

is also important. Thinner woody brown-coal strips occur already at the bottom of the sequence. The high-grade mixing of the Upper and Lower Pannonian types is characteristic of its fauna composition. In addition to the extreme dominancy of the *Limnocardium abichi* (R. H.) *var.* and to other forms spreading from the Lower Pannonian numerous species being later of increased importance occur which are characteristic only of the Upper Pannonian. This sequence is nearly contemporaneous with thel marginal horizons of ungulacaprae — rhomboidea — auricularis as wel as with that of subglobosa of Transdanubia.

5. The middle sequence is lithologically characterized by the appearnce and in the upper section by the predominance of the woody brown-coal strata. The Pannonian inland lake became shallow and was separated into smaller parts. The marshy environment becomes most significant. The most frequent species are the *Viviparus sadleri* (PARTSCH), the *Dreissena serbica* (BRUS.) and the *Limnocardium vutskitsi* (BRUS.). The middle sequence of Algyő can be correlated only in part with the marginal horizons of "balatonica" and "oscillation", this latter one being of wider time extension. The sequence cannot be divided into the "balatonica" and "oscillation" phases. As against the oscillation the gradual filling up is characteristic.
6. At the time of accumulation of the sediments of the upper sequence the filling up had been of considerable size so that the fluviolacustrine environments predominated. The Pannonian inland lake essentially ceased. The sequence cannot be correlated with the upper member of the marginal classification.

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PELECYPODS FROM THE LATE TRIASSIC OF THE SOUTH-GEMERICUM I.

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In this paper it is presented an initiation of formal paleontological description of pelecypods yielded by certain members of the Triassic of South-Gemeric type. These fossils from the families *Halobiidae* and *Monotidae* are not only of great stratigraphic value but also good indicatives of the basinal facies or the vicinity of that. Consequently, these are worthy of not only placing them in faunal lists of geological reports or summaries, but presenting them in text and figures as objects the existence and determinations of which can be easily controlled.

The majority of the material described here came from the Hungarian part of the Gemericum. However, there are references to some specimens, which were firstly collected by Hungarian geologists from Slovakian areas near to the border, the descriptions of which — despite of their importance — were hitherto not available. With this long-need work the present author presumes to return this museum material back into the international scientific current.

In this work pelecypods of five localities are presented to start with.

1. *Daonella (Daonella) lommeli* (WISSMANN): Škalica-hill, to the west of Gemerska Hôrka (Özörény). — Late Ladinian (Longobardian).
2. *Halobia rugosa* GÜMBEL: Rudabánya; Borehole Rb—382, 190 to 193 m depth. — Middle Carnian (Julian).
3. *Halobia charlyana* MOJSISOVICS: Szádvár, to the north of Szögliget. — Middle part of the Lower Norian ("Lac").
4. *Halobia styriaca* (MOJSISOVICS): 300 m south of the SE outlet of Szőlősardó. — Lowert part of the Lower Norian ("Kerri Zone").
5. *Monotis (Monotis) salinaria salinaria* (SCHLOTHEIM): Silicka Brezova (Szádvárborsa), on the southeastern foot of the Dét-hill. — Middle Norian ("Alaun").

Family: Halobiidae DIENER, 1925; emend. ICHIKAWA, 1958
Subfamily: *Halobiinae* ICHIKAWA, 1958
Genus: *Daonella* MOJSISOVICS, 1874
Subgenus: *Daonella* s. str. SPECIALE, 1967
Type species: *Halobia lommeli* WISSMANN, 1841

Daonella (Daonella) lommeli (WISSMANN) 1841

PLATE 1, *Figs. 1—2*

1841. *Halobia lommeli* WISSMANN in MÜNSTER, p. 22; Plate 16, *Fig. 11*
1851. *Halobia lommeli* — EICHWALD, p. 104; Plate 2, *Fig. 1*
1858. *Posidonomya lommeli* — STOPPANI, p. 93; Plate 19, *Fig. 6*

1874. *Daonella lommeli* — MOJSISOVICS, p. 19; Plate 2, *Figs. 13—14*
1878. *Halobia lommeli* — LEPSIUS, p. 356; Plate 2, *Figs. 4a—b*
1892. *Halobia lommeli* — ROTHPLETZ, p. 93; Plate 14, *Figs. 11—12* (non 6)
1893. *Daonella lommeli* — MARIANI, p. 19; Plate 2, *Fig. 5*
1895. *Halobia lommeli* — SALOMON, pp. 83, 114, 154; Plate 5, *Figs. 2—3*
1899. *Daonella* cf. *lommeli* — BITTNER, p. 33; Plate 7, *Figs. 1—2*
1906. *Daonella lommeli* — ARTHABER; Plate 38, *Fig. 4*
1908. *Daonella lommeli* — DIENER, p. 9; Plate 3, *Figs. 1—5*
1912. *Daonella lommeli* — ARTHABER, p. 192; Plate 18, *Fig. 4*
1925. *Daonella lommeli* — SIMIONESCU, p. 9; Plate 1, *Fig. 3*
1952. *Monotis (Daonella) lommeli* — DECHASEAUX, p. 277; *Fig. 64*
1958. *Monotis (Daonella) lommeli* — MÜLLER, p. 458; *Fig. 544*
1961. *Daonella lommeli* — KAJMAKOVIĆ; Plate 4. *Figs 1—2*
1963. *Daonella lommeli* — KOBAYASHI, p. 109; Plate 5, *Fig. 6*
1963. *Daonella lommeli* — STEFANOV, p. 91; Plate 2, *Figs. 1—2*
1964. *Daonella lommeli* — LEONARDI, G; Plate 3, *Fig. 1*
1966. *Daonella lommeli* — SCANDONE and DE CAPOA; Plate 3, *Fig. 1*
1967. *Daonella lommeli* — LEONARDI, P; Plate 24, *Figs. 5—6;* Plate 29, *Fig. 3*
1967. *Daonella lommeli* — SCANDONE; Plate 3, *Figs. 1—2*
1967. *Daonella (Daonella) lommeli* — SPECIALE, p. 1100; Plate 81, *Fig. 5*
1970. *Daonella (Daonella) lomelli* — DE CAPOA, p. 46; Plate 5, *Figs. 1—8*
1971. *Daonella lommeli* — ASTACHOWA, p. 37; Plate 1, *Figs. 1—2*
1974. *Daonella lommeli* — KRYSTYN and GRUBER, p. 283; *Figs. 2a—b*

Material: Fragments of 3 internal and 2 external casts.

Description: As it is shown by the growth lines on one of the casts, length exceeds height. The umbo is orthogyrale and placed before the median line. The broad primary ribs start 1,5—2 mm below the umbo, and their repeated bifurcations toward the margin result in characteristic bunched ribs, which consist of two ribs on the middle of the smaller and four ribs on the larger valves. Concentric rugae are restricted to the umbonal region. Below the hinge line the triangular anterior and posterior parts of the valves are more flattened than the other parts of the valves. The radial ribbing is continuous to the hinge margin on the more flattened parts of the valves (Plate I, *Fig. 2*).

Remarks: The first to recognize the Škalica occurence of this species was L. BARTKÓ (1953), and subsequently this record was reinforced by K. BALOGH (1953, p. 63; 1964, p. 449).

Locality: West of the village Gemerská Hôrka (Özörény), on the western side of the Škalica-hill's top.

Collector: L. BARTKÓ, 1940.

Rock-type: Grey Wetterstein Limestone.

Age: Upper Ladinian (Longobardian).

Reposition: Museum of the Hungarian Geological Institute, Budapest.

Family: Halobiidae DIENER, 1925; emend. ICHIKAWA, 1958
Subfamily: *Halobiinae* ICHIKAWA, 1958
Genus: *Halobia* BRONN, 1830
Type species: *Halobia salinarum* BRONN, 1830

Halobia rugosa GÜMBEL, 1861

1861. *Halobia rugosa* GÜMBEL, p. 275
1863. *Posidonomya semiradiata* SCHAFTHÄUTL, p. 368; Plate 69a. *Fig. 9*
1865. *Halobia haueri* STUR, p. 44
1874. *Halobia rugosa* — MOJSISOVICS, p. 31; Plate 4, *Figs. 7—8*
1906. *Halobia rugosa* — ARTHABER; Plate 42, *Figs. 1—2*

Material: 15 external and 17 internal flattened cast-fragments. 11 specimens are certainly left, 6 specimens are certainly right valves.

Description: The excentric umbo is 6—9 mm high, smooth, only with concentric rugae. It is markedly separated from the radially ribbed part of the obliquely oval valve. The unequal ribs are fine and sharp, sometimes a little wavy or curved after their starting points. The ornament is grouped into clearly visible bunches of 4 or 6 ribs. The growth-rugae continue also on the ribbed valve-parts. At the crossing of these and the radial ribs fine granulation is visible. The posterior edge of the hinge margin is bordered by a very narrow, smooth band. The relatively broad, anterior auricle with ribbing on its lower part can be recognized only on a right and a left valve.

Locality: Rudabánya; Borehole Rb—382, 190 to 193 m depth.

Rock-type: Dark-grey claymarl.

Collector: L. Imreh.

Age: Middle Carnian (Julian).

Reposition: Museum of the Hungarian Geological Institute, Budapest.

Halobia charlyana MOJSISOVICS, 1874

PLATE I, *Fig. 3*

1874. *Halobia charlyana* MOJSISOVICS, p. 27; Plate 4, *Figs. 4—6*
non 1892 *Halobia charlyana* — ROTHPLETZ, p. 94; Plate 14, *Figs. 13—15*
1892. *Halobia cassiana* — ROTHPLETZ, p. 95; Plate 14, *Fig. 18*
1899. *Daonella cassiana* — VOLZ, p. 28
1906a. *Daonella cassiana* — RENZ, p. 33; Plate 3, *Fig. 4*
1906a. *Daonella styriaca* — RENZ, p. 30; Plate 3, *Fig. 3*
1912. *Halobia charlyana* — KITTL, p. 107; Plate 5, *Fig. 7;* Plate 8, *Figs. 14—16*
1924. *Halobia charlyana* — KRUMBECK, p. 290; Plate 108, *Figs. 12—15;* Plate 109, *Figs. 1—5*
1963. ? *Halobia charlyana* — KOBAYASHI, p. 121; Plate 6, *Fig. 20*
1966. *Halobia charlyana* — SCANDONE and DE CAPOA; Plate 4, *Fig. 1*
1967. *Halobia charlyana* — SCANDONE; Plate 8, *Figs. 1—2*
1970. *Halobia charlyana* — DE CAPOA, p. 69; Plate 16, *Figs.*
? 1973. *Halobia charlyana* — ALLASINAZ, GUTNIC and POISSON; Plate 1, *Figs. 1—2*

Material: One right valve (internal cast).

Description: The shape is strongly asymmetric, the anterior hinge margin is remarkably short, the valve-convexity runs obliquely, the undivided halobiid auricle is flatly convex, the umbo without ribs up to 5 mm, the anterior radial ribs are low in section and tend to become finer posteriorly; posterior triangle without ribs. On the basis of these characters the specimen — despite of its juvenile state — can be undoubtedly ranged into the *H. charlyana* group. It bears three, weak growth-rugae altogether; its length/height ratio is 17,8/10,9 (i. e. 1,63).

Locality: From the coquina containing mainly embryonic valves, which was found in boulders at the foot of the ENE slope of the Szádvár, north of Szögliget.

Collector: M. STEFLER, 46/1973.

Age: Middle part of the Lower Norian.

Reposition: Museum of the Hungarian Geological Institute, Budapest.

Halobia styriaca (MOJSISOVICS), 1874

PLATE I, *Fig. 4—9;* PLATE II, *Fig. 1—7*

1874. *Daonella styriaca* MOJSISOVICS, p. 10; Plate 1, *Figs. 4—5*
1874. *Daonella cassiana* MOJSISOVICS, p. 10; Plate 1, *Figs. 2—3* (non Fig. 13)
1874. *Daonella solitaria* MOJSISOVICS, p. 11; Plate 1, *Fig. 6*

1882. *Daonella styriaca* — GEMMELLARO, p. 467; Plate 1, *Figs. 1—2*
1899. *Daonella styriaca* — VOLZ, p. 27; Plate 1, *Fig. 1*
1906a. *Daonella styriaca* — RENZ, p. 30; Plate 3, *Fig. 2* (non 1 and 3)
1906b. *Daonella styriaca* — RENZ, p. 297; Plate 10, *Fig. 1*
1906. *Daonella styriaca* — ARTHABER; Plate 45, *Fig. 1*
1908. *Daonella styriaca* — FRECH; Plate 31, *Fig. 8*
1907. *Daonella styriaca* — WANNER, p. 196; Plate 9, *Fig. 6*
1912. *Halobia styriaca* — KITTL, p. 91; Plate 6, *Figs. 4—5*
1924. *Halobia styriaca* — KRUMBECK, p. 274; *Text-fig. 23;* Plate 9, *Fig. 8;* Plate 10, *Fig. 1—6*
1924. *Halobia cassiana* (MOJS.) emend. KRUMBECK, p. 139; Plate 10, *Fig. 7* and *9—10*
1925. ? *Halobia styriaca* — SIMIONESCU, p. 6; Plate 2, *Fig. 3*
1930. ? *Halobia styriaca* — KUTASSY, p. 205; Plate 3, *Fig. 2*
1955. *Daonella styriaca* — RENZ; Plate 3, *Fig. 5*
1959. *Monotis (Daonella) styriaca* — AUBOUIN; Plate 5, *Fig. 2*
1964. *Halobia styriaca* — DERCOURT; Plate 36
1966. *Halobia styriaca* — SCANDONE and DE CAPOA; Plate 3, *Fig. 2*
1967. *Halobia styriaca* — SCANDONE; Plate 4, *Fig. 3;* Plate 6; Plate 8, *Fig. 3*
1968. *Halobia styriaca* — MUTIHAC; Plate 5, *Figs. 2a—b*
1970. *Halobia styriaca* — DE CAPOA BONARDI, p. 95; Plate 9, *Figs. 1—10;* Plate 10, *Figs. 1—8*
1970. *Halobia cassiana* — DE CAPOA BONARDI, p. 111; Plate 11, *Fig. 1*
1970. *Halobia* cf. *cassiana* (MOJSISOVICS) 1874, emend. KRUMBECK 1921 — DE CAPOA BONARDI, p. 111; Plate 11, *Figs. 2* and *6*
1972. *Halobia styriaca* — BLEAHU ET AL. p. 16; Plate 6, *Figs. 4—7*
1974. *Halobia styriaca* — ALLASINAZ ET AL. Plate 1, *Fig. 4;* Plate 2, *Fig. 2*
1974. ? *Halobia halorica* — ALLASINAZ ET AL. Plate 2, *Fig. 4*

Material: About 30 impressions and internal casts.

Description: Flat or feebly convex valves. Ribs tend to fade towards the hinge margins, so rather broad triangular fields, only with concentric folds appear. Ribs broad and irregular in width. Halobiid auricle cannot be seen (however, this can be due to the flattening of the specimens, too).

On the basis of the ontogenetic changes in the shape and length/height ratio, the specimens studies here can be ranged into the *A* and *B* types of GRUBER, B. (1974). In some specimens (Plate I, *Figs. 4* and *6;* Plate II, *Fig. 7*) the length remains greater than the height during the ontogeny and the number of the ribs in relatively high *(type A);* in other specimens (Plate II, *Fig. 4*) the initially oval shape tends to become subcircular in adult stage, and the number of the primary ribs is comparatively low *(type B)*. The two types are connected by intermediate forms.

Locality: On the cattle-road above the public road, 300 m south of the SE outlet of Szőlősardó.

Rock-type: Grey cherty Pötschen Limestone.

Collector: K. Balogh, 1950.

Age: Lower part of the Lower Norian (Lac—1; Kerri Zone).

Reposition: Museum of the Hungarian Geological Institute, Budapest.

Family: Monotidae FISCHER, 1887. emend. ICHIKAWA, 1958
Genus: *Monotis* BRONN, 1830
Subgenus: *Monotis* s. str. ICHIKAWA, 1958
Type species: *Monotis (Monotis) salinaria* SCHLOTHEIM, 1820

Monotis (Monotis) salinaria salinaria (SCHLOTHEIM), 1820

PLATE III, *Figs. 1—13;* PLATE IV, *Figs. 1—13*

1820. *Pectinites salinarius* SCHLOTHEIM, p. 230
1830. *Monotis salinaria* — BRONN, p. 279; Plate 4, *Fig. 1*
1830. *Monotis inaequivalvis* — BRONN, p. 284; Plate 4, *Fig. 2*
1836. *Monotis salinaria* — GOLDFUSS, p. 139; Plate 121, *Fig. 1*

1836. *Monotis inaequivalvis* — GOLDFUSS, p. 140; Plate 121, *Fig. 2*
1849. *Avicula salinaria* — D'ORBIGNY, p. 200
1879. *Monotis salinaria* — MEDLICOTT and BLANFORD, vol. *2*, p. 637; Plate 2, *Fig. 6*
1892. *Monotis salinaria* — ROTHPLETZ, p. 91; Plate 13, *Figs. 1—3*
1904. *Monotis salinaria* — VOGEL, pp. 217—220; Plate 8
1906. *Monotis salinaria* — DIENER, p. 13; Plate 3, *Figs. 2—3* (non Fig. 1)
1906. *Monotis salinaria* — ARTHABER; Plate 49, *Fig. 2*
1907. *Monotis salinaria* — WANNER, p. 190; Plate 9, *Figs. 2—4*
1912. *Monotis salinaria* — KITTL, p. 169; Plate 10, *Figs. 1—6*
1924. *Monotis salinaria* — KRUMBECK, pp. 250—252; Plate 8, *Figs. 17* and *20* (non Figs. 18—19)
1925. *Monotis salinaria* — DIENER, p. 28; Plate 7, *Fig. 7*
1958. *Monotis (Monotis) salinaria salinaria* — ICHIKAWA, pp. 173—176; Plate 23, *Figs. 2—4* and *11*

Material: 17 left and 16 right valve fragments of which 10 and 5 specimens are inadequate for rib-counting. The length of the largest specimen is 48 mm.

Description: Nearly equal, strongly inequilateral, obliquely oval, posteriorly elongate valves. Length/height ratio 1,30 to 1, 36. Hinge margin short, its anterior part is always shorter than the posterior. The preumbonal flattened area is weakly separated from the other parts of the valve; its margin arches to the hinge margin, forming a blunt angle. The umbo is anteriorly placed, with smooth beak, its convexity — supposing equally-sized valves — is apparently similar on the two valves. The smooth posterior auricle is clearly delimited, with only growth-lines, which cross the posterior hinge margin at right or somewhat greater angles. Its shape is bluntly sloping posteriorly, usually somewhat concave.

The ornament consists of radial ribs, fine concentric growth-lines and especially in the posterior sector, 6 to 10 growth-zones. The primary ribs appear 1,5—2, the secondary ribs 3—8, the tertiary ribs 12 mm from the beak, respectively. The number of the primary ribs is 20—21, of which 5—6 are located within the 45° segment measured from the anterior hinge margin. The ribs increase in number by the intercalation of new ones into intervals of the antecendently formed ribs. The strength of ribs increases toward the valve margin. On larger specimens, above the fifth fold from the umbo, the primary and secondary ribs show a strong, characteristic break (with an anterior and then a posterior curve), or become wavy. This undulation may appear even in the vicinity of the umbo.

Remarks: The specimens studied here can be mostly ranged into the *M. (M.) salinaria salinaria* (SCHLOTHEIM) subspecies within the group of *M. (M.) salinaria* (SCHLOTHEIM). These differ from *M. (M.) salinaria haueri* KITTL by having more than 3 primary ribs within the anterior 45° angle segment. Somewhat coarser and more widely spaced ribs could have been recognized only in a single left valve fragment, however in this specimen rib-counting was impossible, thus its subspecific classification remained uncertain. Taking all thing into consideration, here appears a fairly clear *M. (M.) salinaria salinaria* monoculture.

Locality: On the NW side of the cart-road leading 200 m of SW from the SW outlet of Silicka Brezova (Szádvárborsa), South Slovakia.

Rock-type: Red-coloured Hallstatt Limestone, variegated in some places with lighter grey mottles.

Collector: K. BALOGH (11/1940, VII. 16. BK).

Age: Deeper part of the Middle Norian (Alaunian); *see* MOSTLER, H.—OBERHAUSER, R.—PLÖCHINGER, B. 1967, p. 32).

Reposition: Museum of the Hungarian Geological Institute, Budapest.

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EXPLANATION OF THE PLATES I—IV

All the speciment in natural size — Photo: MRS. PELLÉRDY.

PLATE I

1. *Daonella lommeli* (WISSMANN). — Škalica-hill. — Wetterstein Limestone; Longobardian. — Coll. by L. BARTKÓ, 1940 (No. 24)
2. *The same* (juvenile right valve). — From the same place. — Coll. by L. BARTKÓ, 1940 (No. 21)
3. *Halobia charlyana* MOJSISOVICS. — Szádvár. — Hallstatt Limestone; Julian. — Coll. by M. STEFLER, 46/1973 (No. 14).

4—7. *Halobia styriaca* MOJSISOVICS. — Szőlősardó. — Pötschen Limestone; Lower Norian. — Coll. by K. BALOGH, 1950.
4. Internal cast of a left valve *(No. 15)*
5. The same *(No. 16)*
6. Internal cast of a right valve *(No. 18)*
7. Internal cast of a left valve *(No. 5)*

PLATE II

1—7. *Halobia styriaca* MOJSISOVICS. — Szőlősardó. — Pötschen Limestone; Lower Norian. — Coll. by K. BALOGH, 1950
1. Internal cast of a left valve *(No. 17)*
2. Impression of a right valve *(No. 3)*
3. Internal cast of a right valve *(No. 13)*
4. The same *(No. 2)*
5. Internal casts of two left valves *(No. 20)*
6. Impression of a left valve *(No. 15)*
7. The same *(No. 19)*

PLATE III

1—13. *Monotis (Monotis) salinaria salinaria* (SCHLOTHEIM). — Left valves. — Silicka Brezova (Szádvárborsa). — Deeper part of the Alaunian (Middle Norian); Hallstatt Limestone. — Coll. by K. BALOGH, 1940

1=No. 9	*7*=No. 7
2=No. 11	*8*=No. 38
3=No. 36	*9*=No. 34
4=No. 37	*10*=No. 6
5=No. 33	11=No. 40
6=No. 23	*12*=No. 30

13=No. 31

PLATE IV

1—13. *Monotis (Monotis) salinaria salinaria* (SCHLOTHEIM). — Right valves. — Silicka Brezova (Szádvárborsa). — Deeper part of the Alaunian (Middle Norian); Hallstatt Limestone. — Coll. by K. BALOGH, 1940

1=No. 8	*7*=No. 35
2=No. 27	*8*=No. 39
3=No. 25	*9*=No. 12
4=No. 7	10=No. 28
5=No. 22	*11*=No. 26
6=No. 25	*12*=No. 29/*a*

13=No. 32

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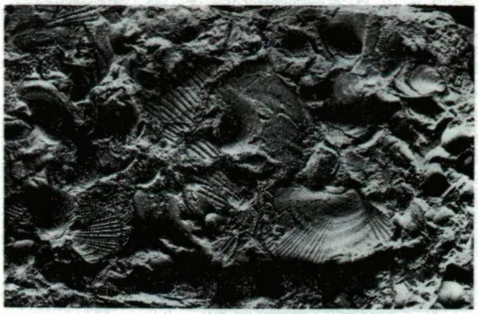

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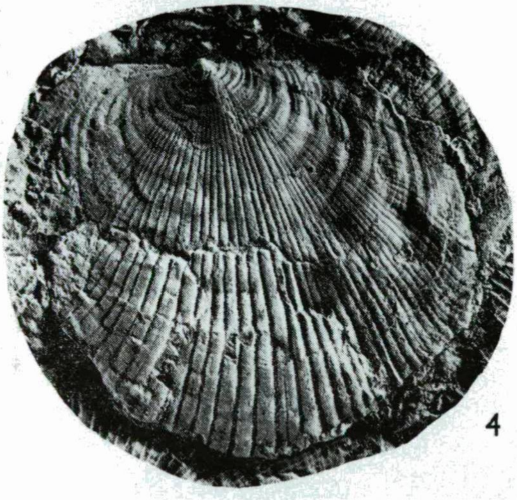

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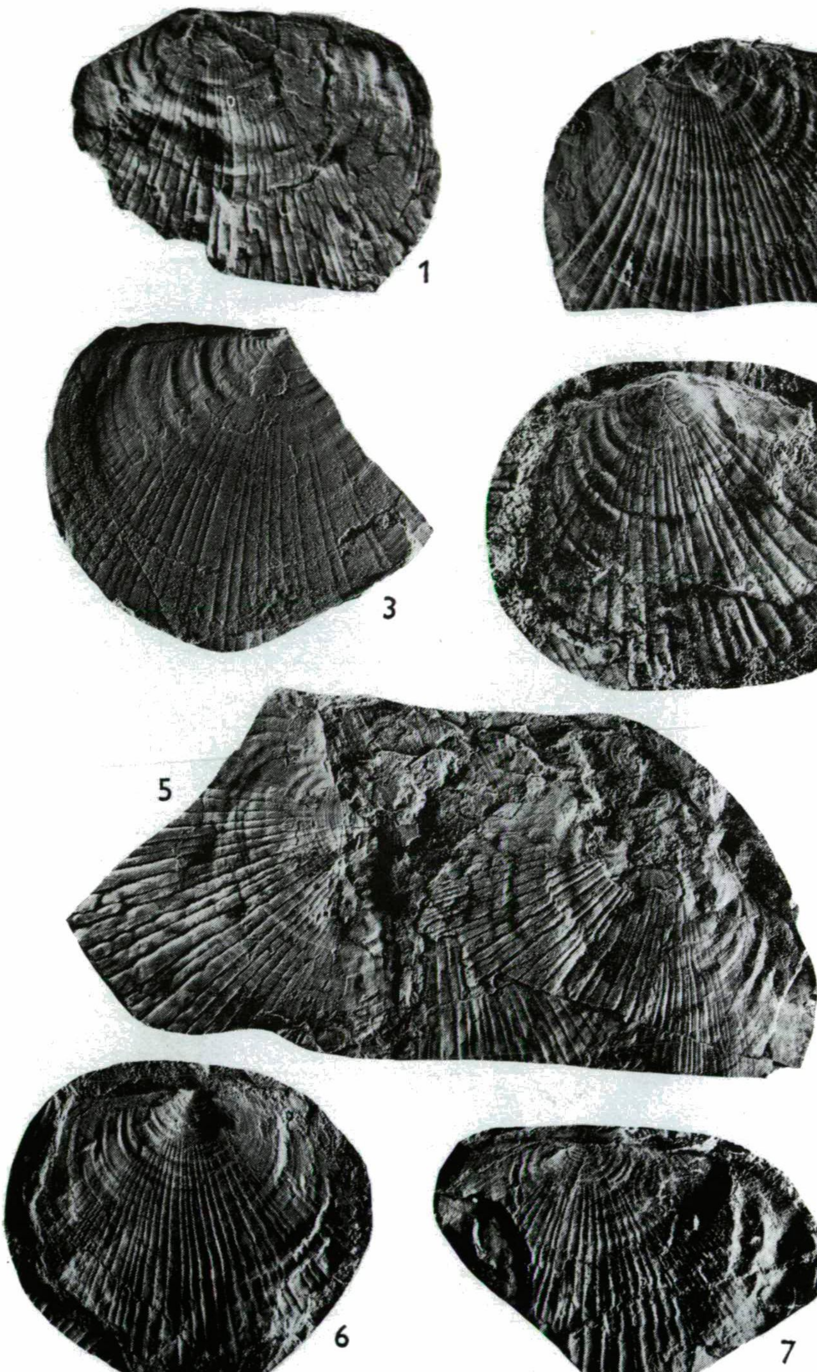
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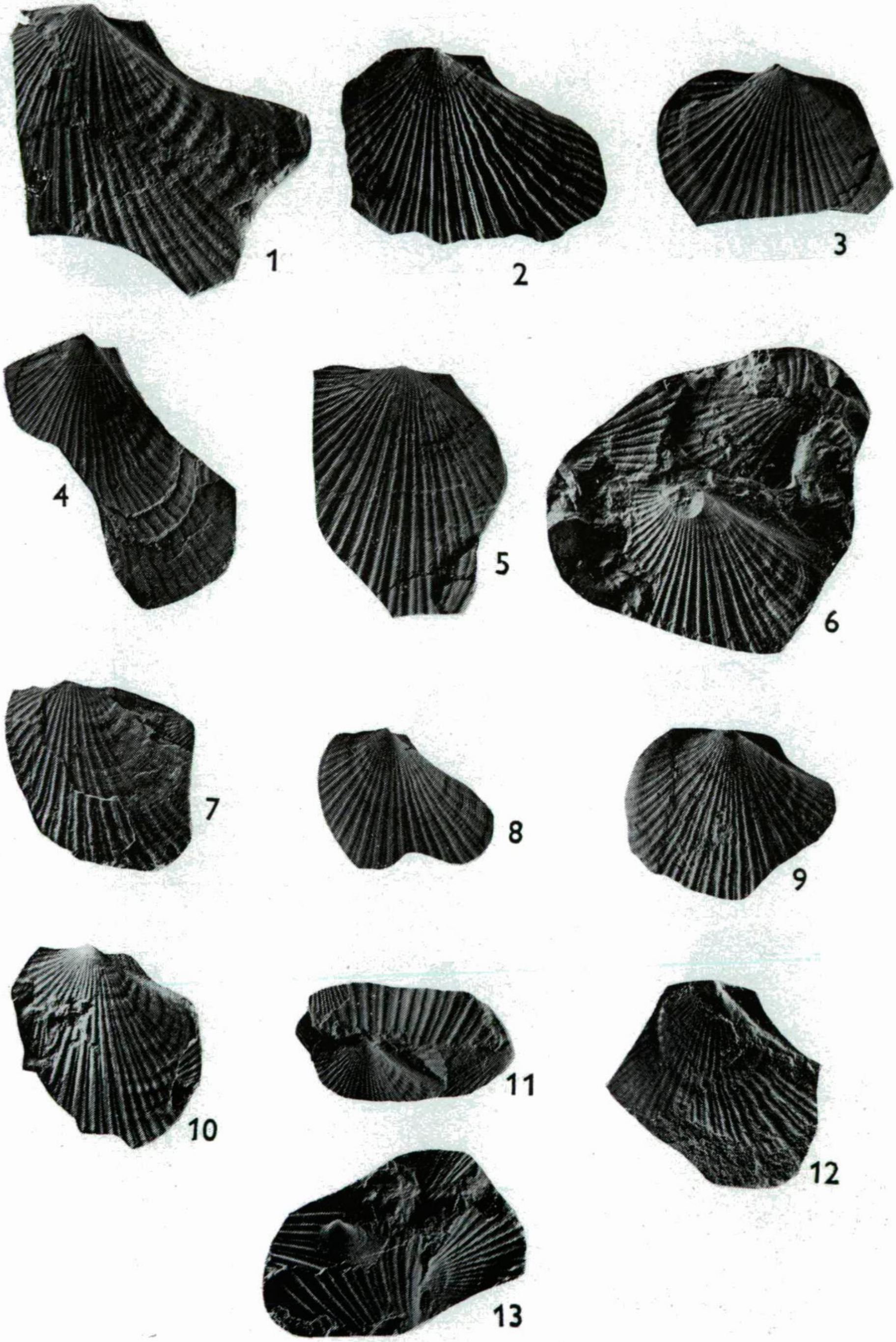
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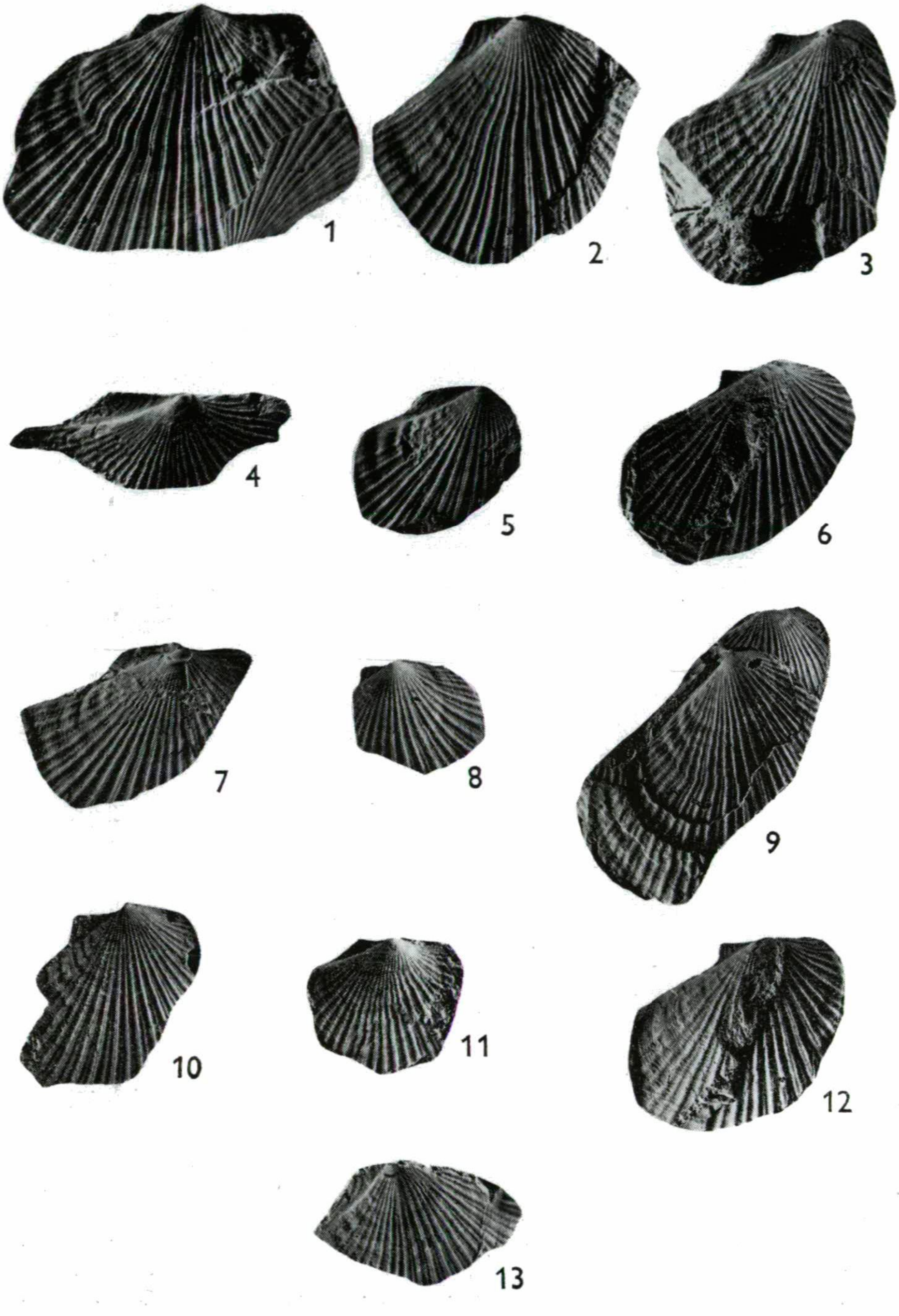
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SPHINCTOZOA FROM THE REEF FACIES OF THE WETTERSTEIN LIMESTONE OF ALSÓHEGY-MOUNT (SOUTH GEMERICUM, WEST CARPATHIANS, NORTHERN HUNGARY)

K. BALOGH and S. KOVÁCS

The W—E striking limestone mass of Alsóhegy-mount of 500 m average elevation and 45 km^2 extension is parted through its length by the Hungarian—Czechoslovakian border *(Fig. 1)*. This mount belongs to the southernmost structural unit of the West Carpathians, i. e. to the South Gemericum. The mount is built up by Wetterstein limestone of Ladinian to Cordevolian age. Its tectonic position is shown

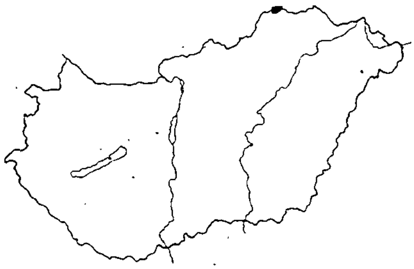

Fig. 1. Position of Alsóhegy in North-Hungary, along the Hungarian—Czechoslovakian border

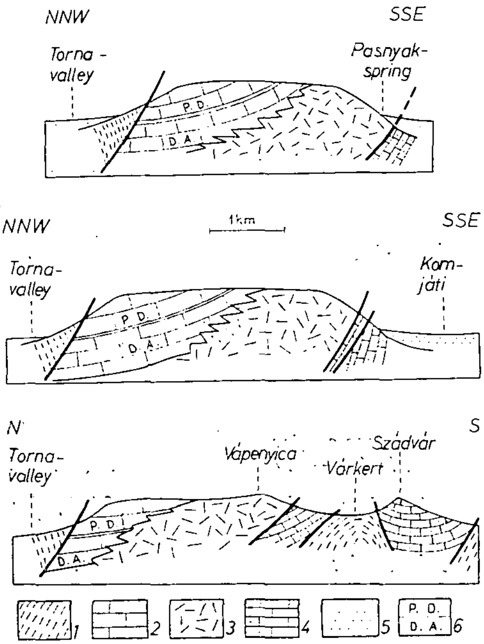

Fig. 2. Rough sketch no the tectonic position and facies arrangement of the limestone masses of Alsóhegy. *1.* Lower Triassic; *2.* Wetterstein limestone, lagoon facies; *3.* Wetterstein limestone, reef facies; *4.* Hallstatt limestone; *5.* Pliocene and Quaternary; *6.* P. D.: *Poikiloporella duplicata* [PIA]; D. A.: *Diplopora annulata* SCHAF.

on the profiles in *Fig. 2.* As it is clear from these illustrations, the Wetterstein limestone which forms the bulk of the mount is separated by northerly dipping tectonic surfaces from the Lower Triassic (Seisian and Campilian) outcropping on the north (in the Torna valley), and from the Upper Triassic of Hallstatt facies appearing on the S and SSE slope of the mount. Within the Wetterstein limestone mass two re-placing facies can be recognized. On the north lagunal facies occurs characterized by *Diplopora annulata* SCHAFH. in the older (Ladinian) and *Poikiloporella duplicata* (PIA) in the younger (Cordevolian) part. On the south, both members of this lagoonal facies are interfingered with reef limestone characterized by the following fossils:

Microproblematica:	*Ladinella porata* OTT
	Lamellitubus cauticus OTT
	Microtubus communis E. FLÜGEL
	Tubiphytes obscurus MASLOV
	Baccanella floriformis PANTIĆ
Inozoa:	*Peronidella* sp.
	Corynella sp.
	Leiospongia sp.
Hydrozoa:	*Spongiomorpha* sp.
Hexacorallia:	*Montlivaltia* sp.
	Thecosmilia sp.
Sphinctozoa:	*Follicatena cautica* OTT
	Vesicocaulis depressus OTT
	? Cystothalamia sp.
	Uvanella irregularis OTT
	Colospongia catenulata catenulata OTT
	Amblysiphonella sp.
	Dictycooelia manon (MÜNSTER)
	Cryptocoelia cf. *zitteli* STEINMANN
	Stylothalamia dehmi OTT

The majority of the sphinctozoans listed here suggests Ladinian—Cordevolian age, only *Uvanella irregularis* and *Stylothalamia dehmi* range up into the Julian (OTT, E. 1967*b*, p. 61).

The *Sphinctozoa* material described here is reposited in the collection of Geologic and Palaeontologic Department of the József Attila University, Szeged.

Ordo: *Sphinctozoa* STEINMANN, 1882
Superfamily: *Aporata* SEILACHER, 1962
Family: Celyphiidae LAUBENFELS, 1955
Genus: *Follicatena* OTT, 1967

Follicatena cautica OTT, 1967

PLATE I, *Fig. 2;* PLATE III, *Fig. 2*

Follicatena cautica OTT (1967*b*, p. 22; Plate I, *Figs. 1—7*). — *F. cautica*, JABLONSKÝ (1971, p. 336; *Figs. 1—2*). — *F. cautica*, JABLONSKÝ (1974, p. 190; Plate 17. *Fig. 1*).

Material: 3 thin sections: No. 2/1972/c; 2/1972/E; 8/1972. — 1 peel: No. 222/1950 BK.

Diagnosis: OTT, E., 1967*b*, p. 32.

Description: Incomplete specimens. The 3 thin sections show more or less circular sections of single, separated segments of 2,45×2,52 mm, 3,64×4,20 mm and 4,41 mm diameter, respectively. The maximal wall-thickness in all specimens is 0,34 to 0,35 mm, but certain portions of the wall attains only 0,08—0,15 mm thickness. In the wall of specimen No. 8/1972 some triangular ostia appear, without penetration; their bottom-width is 0,1 mm, length 0,14 mm. In the specimen No. 2/1972/C two opposite ostia of 0,14 mm width completely penetrate the wall. On the third, fragmentary specimen ostia cannot be seen. The light-coloured spots of 0,02—0,1 mm diameter in the wall of specimen Nr. 8/1972 are presumably agglutinated grains.

Because of the cut orientation of the sections no sieve-fields are visible in the specimens. The inner parts of all the three specimens are filled with vesiculae (Plate I, *Fig. 2;* Plate III, *Fig. 2*).

Replica No. 222/1950/BK. (Plate I, *Fig. 2*) shows 5 chambers of a curved catenulate stem of originally 6 to 7 chambers. The diameters of the largest chambers are 5,39 to 5,43 mm, wall-thickness is 0,15 to 0,40 mm. The wall is doubled at the junction of the segments. The ostia tend to narrow outwards (bottom 0,14 to 0,35 mm). A 3 mm long basinal portion of a chamber can be regarded, on the basis of the densely appearing ostia, as a sieve-field.

Remarks: On the basis of their dimensions, thickness, imperforate wall, doubled walls, vesicular filling structure, the forms described here — despite of the fragmentary preservation — can be arranged into the species *Follicatena cautica* OTT.

Locality: On the side of the forestry road from Bódvaszilas to Szabó-parlag and western slope of the Vápenyica-hill. — Wetterstein reef limestone.

Stratigraphic range: Ladinian to Cordevolian.

Genus: *Vesicocaulis* OTT, 1967

Vesicocaulis depressus OTT, 1967

PLATE II, *Fig. 3*

Vesicocaulis depressus OTT (1967b, pp. 26—28; Plate 3, *Figs. 1—4*). — *V. depressus*, Jablonský (1971, p. 337; *Fig. 3*).

Material: 2 thin sections: No. 2/1972/G; 2/1972/H. — 1 peel: No. 2/1972/G.

Diagnosis: DIECI, G.—ANTONACCI, A.—ZARDINI, R. (1968) in JABLONSKÝ, 1971. p. 337.

Description: Thin section No. 2/1972/G shows a tangential cut of a subcylindrical stem of 3,85 mm diameter, with 3 shield-like overlapping chambers. Its 2,0—2,2 mm wide central channel system consists of 4—5 interwoven tubuli of 0,2—0,3 mm diameter, which form a characteristic central reticular structure. In the tubes vesiculae also occur. The height of the segments is 0,6 to 0,7 mm, and they show only vesiculae. Wall-thickness 0,15—0,20 mm. In the uppermost chamber two ostia of 0,03—0,06 mm diameter are visible. The replica made from this same specimen seems to be more complete, it shows five segments. In thin section No. 2/1972/H shows a fragment of a similarly built, upward narrowing stem of 3,3—3,9 mm diameter, with traces of the central channel system. Wall-thickness 0,06—0,15 mm, the width of the isolated ostia is 0,042 mm.

Remarks: The specimens resemble the section figured by OTT, E. (1967*b*) in his Plate 3, *Fig. 3*.

Locality: On the side of the forestry road from Bódavszilas to Szabó-parlag. — Wetterstein reef limestone.

Stratigraphic range: Ladinian to Cordevolian.

Superfamily: *Porata* SEILACHER, 1962
Family: Cystothalamiidae GIRTY, 1908
Genus: *Cystothalamia* GIRTY, 1908

? *Cystothalamia* sp.

PLATE III, *Fig. 1*

Material: 2 peels: No. 25/1972; T-197/1974.

Description: Oblique sections of glomerate, subcylindrical stems of 5 to 7 mm mm diameter, which avoid the central channel. The chambers are 1,2—2,8 mm wide and 0,8—2 mm high, and are filled with vesiculae. Pores of 0,1—0,2 mm diameter appear both on the outher and inner walls. Wall-thickness 0,12—0,25 mm.

Remarks: The sections suggest those of *Cystothalamia bavarica* (OTT, E. 1967*b*, pp. 36—37; Plate 1, *Fig. 8;* JABLONSKY, E. 1971, p. 340; *Figs. 5—6*), but this shows central channel, too. As the sections avoid the central channel, a closer determination is impossible.

Locality: On the side of the forestry road from Bódvaszilas to Szabó-parlag and the western slope of the Vápenyica-hill. — Wetterstein reef limestone.

Stratigraphic range: Ladinian to Cordevolian.

Genus *Uvanella* OTT, 1967

Uvanella irregularis OTT, 1967

PLATE II, *Figs. 5—6*

Uvanella irregularis OTT, E. (1967b, pp. 38—40; Plate 3, *Fig. 8*; Plate 5, *Figs. 1—3*; Plate 8, *Fig. 1*). — *U. irregularis*, OTT, E.—KRAUS, O. (1968, pp. 275—276; Plate 19, *Fig. 6*). — *U. irregularis*, JABLONSKÝ (1971, pp. 341—342, *Fig. 7*). — *U. irregularis*, OTT (1972, Plate 1, *Fig. 1*). — *U. irregularis*, JABLONSKÝ (1974, pp. 192—194; Plate 17, *Fig. 3*).

Material: 6 thin sections: No. T-193/A and B (sections of the same specimen); T-197/A; 4/1972/B; 25/1972/B; 35/1973/J. — 1 peel: No. T-193.

Diagnosis: OTT, E. 1967*b*, p. 38.

Description: Radial and tangential sections of incrusting nodules of nearly 2 cm in size. The body is an agglomerate of irregular chambers. The size of the chambers varies remarkably; the length (1—3,5 mm) sometimes exceeds multiply the height (0,3—2 mm). Walls with striped structure and comprise smaller cavities; their thickness varies between 0,08 and 0,5 mm. Walls usually imperforate, the chambers are connected only in some places with openings of 0,08—0,5 mm diameter. The light spots visible in the thicker walls can be due to the rock-particles agglutinated during the growth. The coarse and irregularly-walled vesiculae are particularly common in the lower part of the body. Other filling structure or central channel is missing.

Locality: Vecsembükk; on the side of the forestry road from Bódvaszilas to Szabó-parlag; the southern and southwestern slope of the Vápenyica-hill. — Wetterstein reef limestone.

Stratigraphic range: Ladinian to Middle Carnian.

Family: Sebargasiidae STEINMANN, 1882
Genus: *Colospongia* LAUBE, 1865

Colospongia catenulata catenulata OTT, 1967

PLATE I, *Fig. 5*

Colospongia catenulata OTT (1967b, pp. 32—34; Plate 7, *Figs. 3—4;* Plate 8, *Figs. 1—5*). — *C. catenulata*, OTT (1972, Plate 1, *Fig. 1*). — *C. catenulata catenulata* JABLONSKÝ (1974, pp. 194—195; Plate 68, *Fig. 1*).

Material: 1 thin section: No. 35/1973/F. — 2 peels: T-124/1974; 191/1974/a.
Diagnosis: OTT, E. 1967*b*, p. 32.
Description: Linearly arranged spheroidal chambers. Central tube or filling structure are missing, vesiculae cannot be seen. The shape of the chambers is circular in tangential section, and somewhat elongate, pyriform in axial section. Their size is nearly equal within the same specimen. The chamber-diameter measures between 1,3 and 3,5 mm, the height index is 1 to 1,15. Wall-thickness 0,1—0,4 mm. The chambers are connected to each other and to the outside by dense, identical pores. The pores are tapering outward, their diameter is 0,1 to 0,2 mm. The recrystallization of the walls may obliterate the perforation. Equatorial ostia cannot be seen.
Remarks: On the basis of all important features the specimens can be well identified with the specimens of this species given in the literature.
Locality: NNW from the Pasnyak-spring, on the edge of the plateau; southern slope of the Vápenyica-hill. — Wetterstein reef limestone.
Stratigraphic range: Ladinian to Cordevolian.

Genus: *Amblysiphonella* STEINMANN, 1882

Amblysiphonella sp.

PLATE I, *Fig. 1*

Material: 1 thin section: No. 17/1972/D
Description: 20 mm long oblique section of a catenulate stem of 8 to 10 mm diameter. The 1,6—2,0 mm high chambers are presumably arranged annularly around the central channel, but without complete encircling. The segments are connected with pores of 0,1 to 0,25 mm diameter. Filling structure, as well as vesiculae, are missing.
Remarks: Because of the oblique section, the closer determination is impossible.
Locality: On the side of the forestry road from Bódvaszilas to the Szabó-parlag. — Wetterstein reef limestone of Ladinian to Cordevolian age.

Family Verticillitidae STEINMANN, 1882
Genus: *Dictyocoelia* OTT, 1967

Dictyocoelia manon (Münster, 1841)

Plate II, *Figs. 1—2*

Dictyocoelia manon (MÜNSTER) in OTT (1967b, pp. 40—42; Plate 7, *Figs. 1—2;* Plate 9, *Figs. 1—4;* cum synonimis). — *D. manon*, JABLONSKÝ (1974, pp. 196—197; Plate 68, *Fig. 2;* cum synonimis).

Material: 1 thin section: 2/1972/H.
Diagnosis: OTT, E. 1967*a* p. 56.
Description: The oblique section of a catenulate, curved specimen shows 4 segments. The diameter of the most entire chamber is 5 mm. The clearances of the irregular network of the coarse, reticular filling structure are divided by vesiculae. The filling test is lamellar in structure. The central channel is of 0,9 mm in diameter, without visible vesiculae. The fine pores, which perforate the outer wall, can be seen very rarely; no vesiculae.
Remarks: On the basis of the coarseness of the filling texture, the specimen is near to those of JABLONSKÝ, E. (1974; Plate 68, *Fig. 2*) and KRAUS, O.—OTT, E. (1968; Plate 20, *Fig. 1*).

Locality: On the side of the forestry road from Bódvaszilas to Szabó-parlag. — Wetterstein reef limestone.

Stratigraphic range: Ladinian to Cordevolian.

Family: Cryptocoeliidae STEINMANN, 1882
Genus: *Cryptocoelia* STEINMANN, 1882

Cryptocoelia cf. *zitteli* STEINMANN, 1882

PLATE I, *Figs. 3—4;* PLATE III, *Fig. 5*

Cryptocoelia zitteli STEINMANN (1882, pp. 176—177; Plate 7, *Figs. 1—2;* Plate 8, *Fig. 5;* Plate 9, *Fig. 4*). — *C. zitteli*, SEILACHER (1962, p. 751). — *C. zitteli*, OTT, E. (1967b, pp. 42—44; Plate 9, *Figs. 5—7*). — *C. zitteli*, JABLONSKÝ (1971, pp. 342—343, *Figs. 8—9*). — *C. zitteli*, JABLONSKÝ (1973, pp. 185—187; Plate 1, *Figs. 1—2;* Plate 2, *Figs. 1—2*). — *C. zitteli*, JABLONSKÝ (1974, p. 198; Plate 68, *Fig. 3;* cum synonimis).

Material: 3 thin sections: No. 223/1950/BK; 3/1972/D; 35/1973/B.

Diagnosis: STEINMANN 1882, p. 176.

Description: Single, curved stems. The diameter of the segments is 1,8 to 2,9 mm; that of the larger chambers within the single stem is uniform. Because of the cut-effect, the apparent height of the segments is between 1,4 and 2,8 mm, most commonly 2,2 to 2,4 mm. The trabecular filling structure consists of irregularly shaped, sometimes anastomizing pillars, which arise from the chamber-roof. These pillars are coarse initially, but narrow downward, and reaching the base of the chamber become thick again. In the studied sections central channel cannot be seen. In the tubes, between the pillars, vesiculae are common. These tubes appear in cross section as white, irregular spots of 0,08—0,2 mm diameter, which are arranged near the chamber wall. The diameter of the pillars on the chamber-roof is 0,1 to 0,4 mm, their structure is microlamellar. The wall is penetrated by sparse pores of 0,08 to 0,16 mm diameter.

Remarks: The most characterisitic features of the studied specimens resemble those of species *Cryptocoelia zitteli* On the other hand, these differ from the figures in the literature in having greater chamber height and smaller diameter. Although, these partly can be due also to cut-effect, it seems more reasonable to refer only to the group in naming.

Locality: On the side of the forestry road from Bódvaszilas to Szabó-parlag; southwestern part of the Vápenyica-hill. — Wetterstein reef limestone.

Stylothalamia dehmi OTT, 1967

PLATE III, *Figs. 3—4;* PLATE IV. *Figs. 1—4;* PLATE V, *Figs. 1—3*

Stylothalamia dehmi OTT (1967*b*, pp. 44—46; Plate 10, *Figs. 1—5*). *S. dehmi*, JABLONSKÝ (1971, pp. 343—345; *Fig. 10*).

Material: 1 hand-specimen rendered out on the rock surface: No. 6/1972. — 6 thin sections: No. e/1971; 6/1972/B; 8/1972; 11/1972/A and C (from the same specimen); 11/1972/F; 35/1973/E; T-197/1974/B.

Diagnosis: OTT, A. 1967*b*, p. 44.

Description: The stems of 8 to 12 mm diameter and 15 to 20 mm height are built up by shield-like, overlapping flat segments. The segment-height is 0,8—1,2 mm generally, 1,6 mm maximally and 0,3—0,4 mm in the oldest chambers.

The trabecular filling structure consists of 0,09 to 0,27 (most commonly 0,15) mm wide, irregularly spaced pillars. The shorter pillars are stalactite- or stalagmite-like, the larger ones span the entire chamber. These may tend to be thicker at their base, here hollows may appear. Vesiculae are common both in the lower and upper segments.

Wall-thickness 0,10 to 0,24 mm, most commonly about 0,15 mm. In some specimens towards the older chambers more and more endodermal layers can be seen as depositing onto the inner walls, pillars and even vesiculae. Consequently, in these specimens the older chambers are markedly filled endodermally. The wall is densely perforated, the diameter of the pores is 0,05 to 0,10 mm. The pores narrow to about une-third outwardly.

The retrosiphonate central channel is shown only on the hand-specimen (Plate IV, *Fig. 1*) and in the thin section No. 35/1973/E (Plate IV, *Fig. 2*). Its diameter is 1,5 to 2,0 mm in the former and 0,09 mm in the latter. The connection between the chambers and the central channel is maintained by pores of the same diameter as those penetrating the walls.

Thin section No. T-197/1974/B. shows a juvenile specimen consisting of 3 segments and an initial (?) chamber with strongly thickened wall (Plate III, *Fig. 3*). The shape is club-like, with 2,5 mm height and 2,3 mm maximal thickness. The height of the segments is 0,4 mm, wall-thickness 0,10 to 0,15 mm. The diameter of the pores (0,12 to 0,14 mm) is somewhat greater than that of the adult speciments. Vesiculae are not visible. Into the upper segments protrude trabeculae of 0,1 mm diameter.

Remarks: The shape of the hand-specimen is more elongated and the skeletal structure of the thin sections is somewhat coarser as compared to those figured from the Raiblian beds by OTT (1967*b*, *Text-fig. 4;* Plate 5, *Figs. 5—6;* Plate 6; Plate 10, *Figs. 1—5*). However, the subspecific separation is unprovable for the present. OTT presumed two, retrosiphonate and asiphonate ways of growth of this species. In our opinion the asiphonate growing is unproved, because the sections may easily avoid the narrow central channel.

The appearance of hollows in the bases of the pillars can be explained by taking into consideration that the pillar, during its thickening, may overgrow several pores of the chamber-roof.

Locality: Vecsembükk (near to the Gőte-sump); on the side of the forestry road from Bódvaszilas to Szabó-parlag; southern and western slope of the Vápenyica-hill.

Stratigraphic range: The holotype came from the Raiblian beds (Julian). The specimen of JABLONSKÝ was yielded by an occurrence regarded as Ladinian (?) in age. The bulk of the specimens studied here came from the western part of the Alsó-hegy-moung, where the reef facies of the Wetterstein limestone interfingers with the *Poikiloporella duplicata*-bearing lagoonal facies. Consequently, their age is probably Lower Carnian (Cordevolian).

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EXPLANATION OF THE PLATES I—V

Plate I

1. *Amblysiphonella* sp. — Oblique longitudinal section. — 17/1972/D. — Along the forestry road leading to Szabó-parlag. — 3x
2. *Follicatena cautica* Ott. — Oblique longitudinal peel of a curved stem with 5 visible chambers. 222/1950. BK. — SW side of the Vápenyica-hill. — 3x
3. *Cryptocoelia* cf. *zitteli* Steinmann. — Oblique longitudinal section of a curved stem. — 35/1973/B. — SW part of the Vápenyica-hill. — 5,3x
4. *The same.* — 3/1972/D. — Along the forestry road leading to Szabó-parlag. — 4,8x
5. *Colospongia catenulata catenulata* Ott. — Oblique longitudinal peel. — T-124/1974. — Towards NNW from the Pasnyak-spring, where the zigzag road cuts the edge of the limestone-plateau. — 11x

Plate II

1. *Dictyocoelia manon* (Münster) (right); *Vesicocaulis depressus* Ott (left); *Celyphia* sp. (below). — 2/1972/H. — Along the forestry road leading to Szabó-parlag. — 5,8x
2. *Dictyocoelia manon* (Münster). — Enlarged from the Fig. 1. — Oblique section of a curved, catenulate stem with 4 segments. — 11x
3. *Vesicocaulis depressus* Ott. — Tangential section. — 2/1972/G. — Along the forestry road leading to Szabó-parlag. — 11x
4. *Uvanella irregularis* Ott. — Radial section of an incrusting clump. — T-193/A. — Vecsembükk. — 4,8x
5. *Uvanella irregularis* Ott. — Tangential section with vesiculae. — 35/1973/J. — From the SW side of the Vápenyica-hill. — 4,7x

Plate III

1. ? *Cystothalamia* sp. — Oblique section of the glomerate stem with vesiculae. — T-197/1974. — West side of the Vápenyica-hill. — 11x
2. *Follicatena cautica* Ott. — Cross-section of a single segment with vesiculae. — 8/1972. — Along the forestry road leading to Szabó-parlag. — 15x
3. *Stylothalamia dehmi* Ott. — Juvenile specimen. — T-197/1974/B. — From the west side of the Vápenyica-hill. — 15x
4. *Stylothalamia dehmi* Ott. — 3 segments with trabeculae and vesiculae. — 11/1972/C. — Along the forestry road leading to Szabó-parlag. — 30x
5. *Cryptocoelia* cf. *zitteli* Steinmann. — Oblique section with trabeculae and vesiculae. — 223/1950. BK. — SW part of the Vápenyica-hill. — 11x

Plate IV

1—4. *Stylothalamia dehmi* Ott
   1. Hand-specimen rendered out on the rock surface. Nearly longitudinal section with the filling of the central channel. —6/1972. —3x
   2. Slightly oblique cross-section with central channel and osculum (above). — 35/1973/E. — South side of the Vápenyica-hill. — 11x
   3. Oblique longitudinal section with trabeculae and vesiculae. — 6/1972/B. — 5x
   4. The same. — 11/1972/C. — 6x
   (*1, 3, 4;* Along the forestry road leading to Szabó-parlag).

Plate V

1—3. *Stylothalamia dehmi* Ott
   1. A segment with trabeculae and close roof-pores. — 11/1972/C. — 30x
   2. Trabecular filling structure. — 11/1972/A. — 30x
   3. Endodermal filling of lamellar structure in the older chambers. — 11/1972/C. — 30x
(All the specimens were collected along the forestry road leading from Bódvaszilas to Szabó-parlag.)

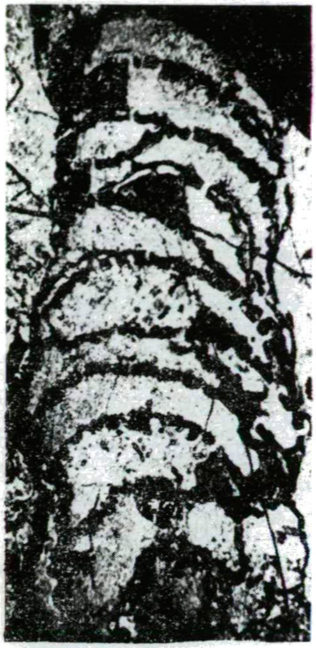

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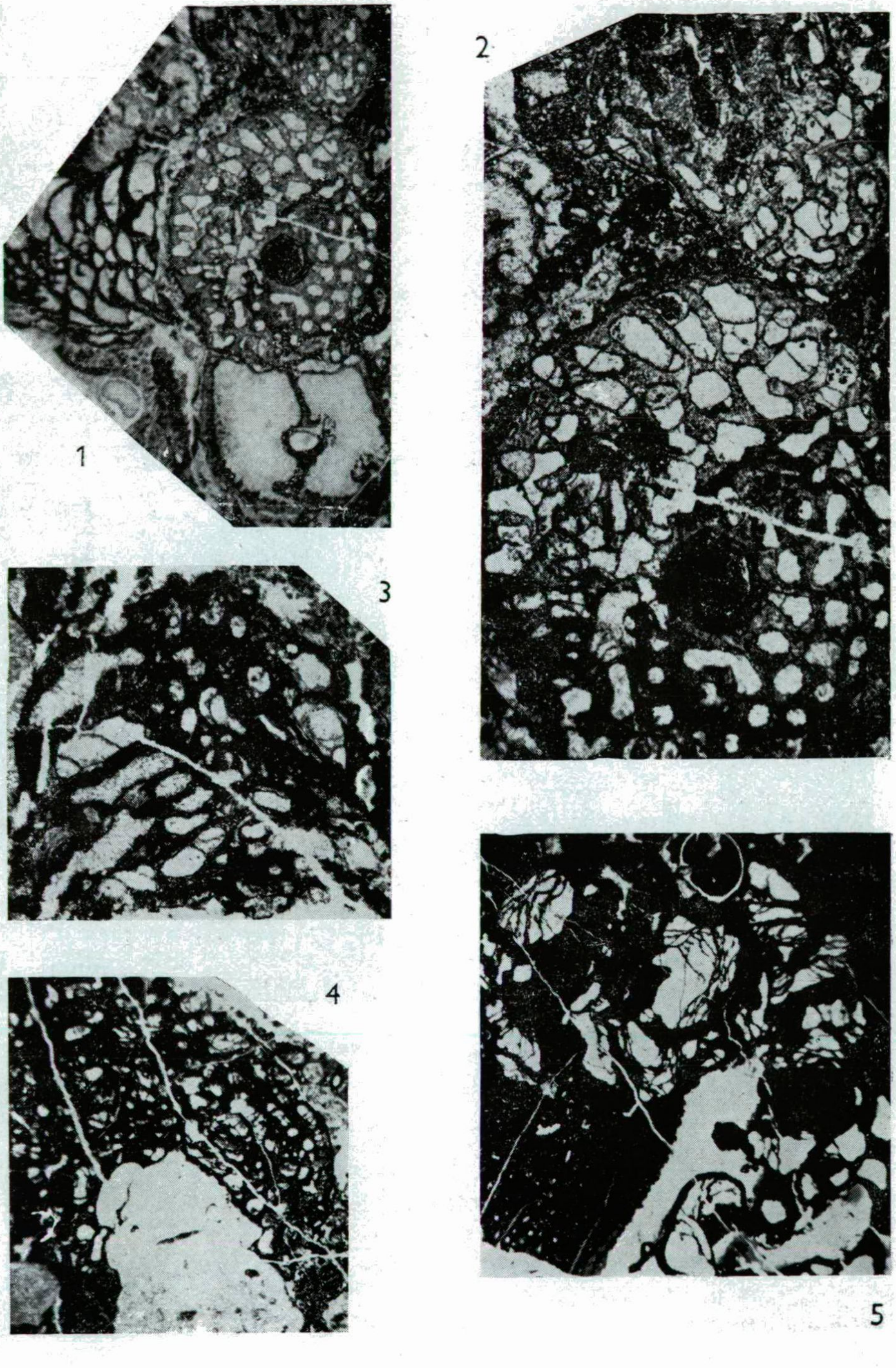
PLATE II



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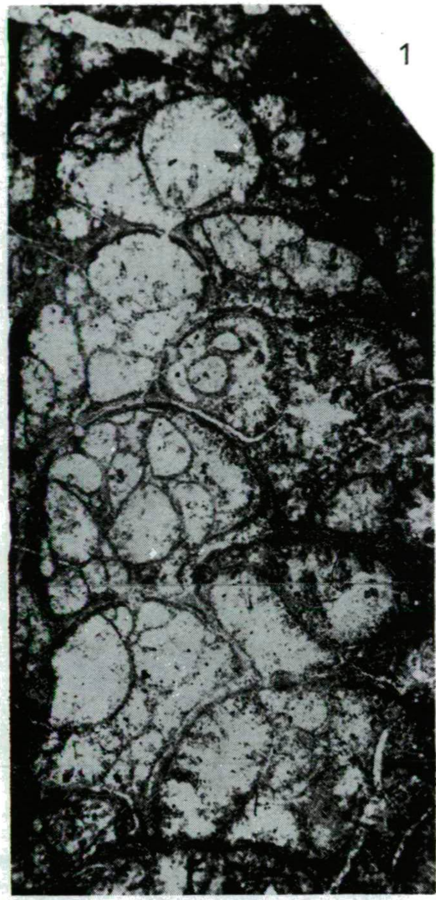

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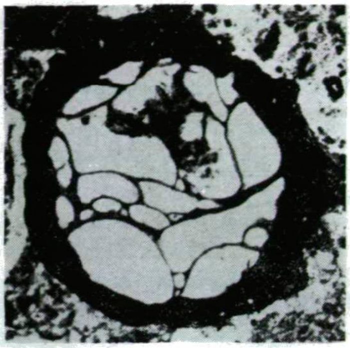

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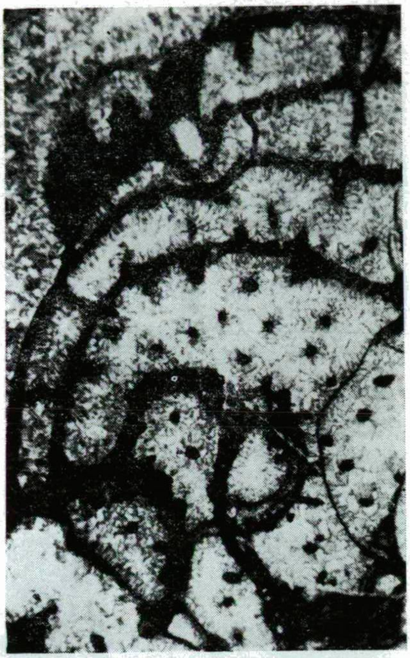

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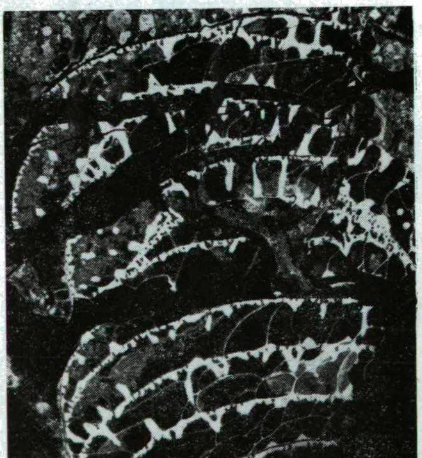

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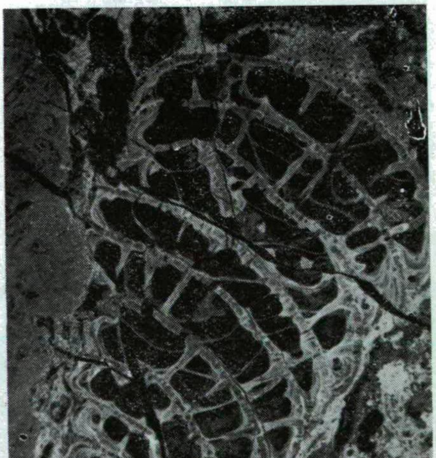

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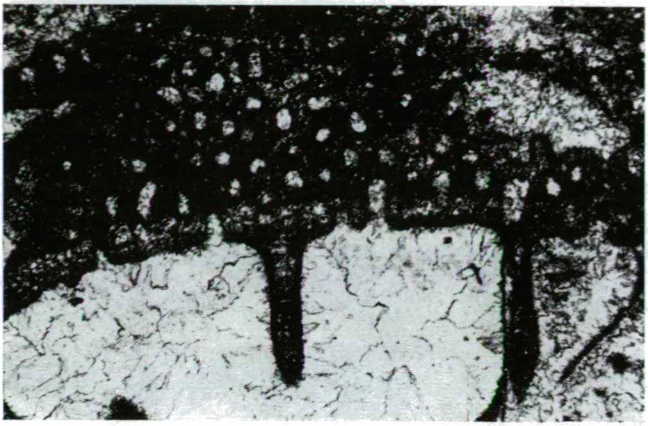

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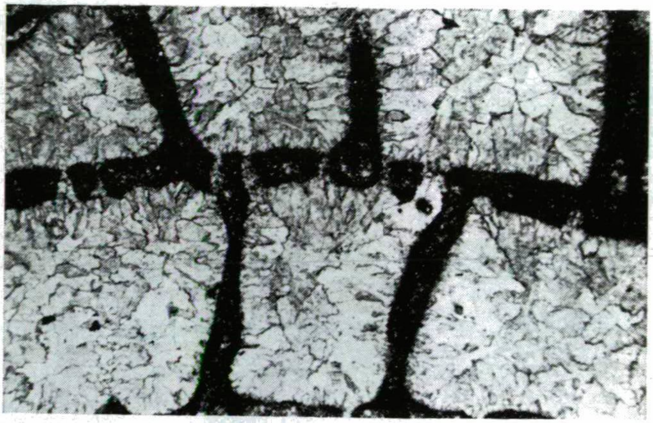

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Acta Mineralogica-Petrographica, Szeged, XXII/2, 311—337, 1976

NEWLY RECORDED AGGLUTINATED FORAMINIFERA FROM THE QUSSEIR SHALES IN GEBEL DUWI AND ABU HAD, EASTERN DESERT, EGYPT

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ABSTRACT

This paper describes and illustrates 45 agglutinated foraminiferal species recorded, for the first time, from the Qusseir Shales in Gebel Abu Had and Duwi, Eastern Desert, Egypt. Through the analysis of the reported fauna, 4 agglutinated zones were proposed and defined. On the basis of these biozones, the age of the Qusseir Shales is assigned to Campanian and Maestrichtian.

INTRODUCTION

The Qusseir Shales are a series of greyish green to dark grey, laminated shales alternating with yellowish and brownish ferruginous fine-grained sandstone beds.

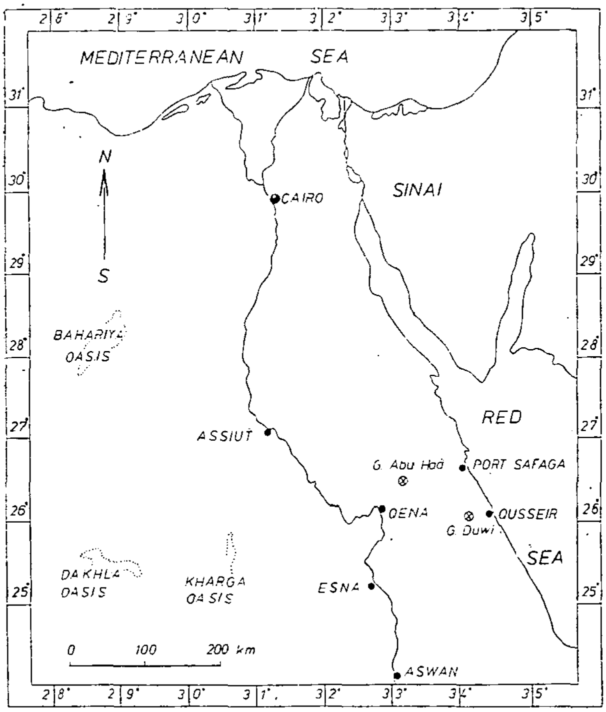

Fig. 1. Location Map

These shales were first described in detail by YOUSSEF (1949) in Qusseir district and were referred by him as "Variegated Clays". The same author (1957) named these shales as "Kosseir variegated shales" and described them as a multicoloured member that overlaines the "Nubia sandstone" and marked above by the appearence of the lowermost phosphate beds (Duwi Formation).

Ghorab (1956) considered the thick succession of variegated shales in Qusseir area as a separate formation which he named as "Qusseir Formation", with its type locality in Gebel Duwi, Red coast.

EL NAGGAR (1970) raised the Nubia sandstone to a group status. The Nubia group was suggested by this author to include, besides the dominating arenaceous units, the overlaying variegated shales (Qusseir Shales) as well as the following phosphate succession (Sibaiya Formation).

The Qusseir Shales have a wide horizontal extent in Egypt. These have been described from such widely separated areas in Egypt, as Dakhla, Kharga Oases to the west, the Nile Valley and the Qusseir Safage to the east, even from Central Sinai *(Fig. 1)*.

BIOSTRATIGRAPHY

The age of the Qusseir Shales was subject of a great controversy in the Egyptian stratigraphy for a long time ago, since they are devoid of mega- and microfossils that can detect the age definitely.

BLANCKENHORN (1900), STROMER and WELLAR (1930), ZDANSKY (1934) have identified the following *Vertebrate* fauna from the bone bearing ferruginous brecciated beds intercaleted the variegated shales in Mahamid district: *Schizonia stromeri, Plethodus* sp., *Amoedus angustus, Suchodus lybicus.* They considered these fossils to be of Upper Cretaceous and most probably Upper Senonian.

According to YOUSSEF (1957) this formation is of "probable Campanian age".

FARIS and HASSAN (1959) separated and identified a rich *Ammonite* fauna from the upper part of similar shales in Safage area. In their opinion these shales may have an age older than the Maestrichtian.

AWAD and GHOBRIAL [1965] considered the lowest fossiliferous zones of the Phosphate Formation, in El Kharga Oasis, to be of Lower Maestrichtian age, and the variegated shales to be prae-Maestrichtian.

ABDEL RAZIK (1966, 1967) found also these bands of bone beds intercalating the lower part of the variegated shales in the area between Idfu and Quena and assigned a Campanian age to these. The same author regarded the variegated shales in Gebel Anz, Qusseir area to be of Campanian age and at least its upper part is of Lower Maestrichtian.

EL NAGGAR (1966) recorded some *Vertebrate* species from the bone bed intercalating the shales in Gabal Nagaa El Sheikh. Zhis author considered the Nubia sandstone and variegated shales to be of Campanian and prae-Campanian age.

HERMINA (1967) considered the variegated shales are definitely Lower Maestrichtian in the north-western approaches of El Kharga Oasis, Western Desert, Egypt.

The present work is the first which determines the biostratigraphic age of the Qusseir Shales on micropaleontological basis. For this purpose about 50 samples were collected from this formation at Gebel Abu Had and Gebel Duwi (the type locality of this formation). These samples are rich in agglutinated smaller *Foraminifera.*

The Qusseir Shales Formation is subdivided into 4 biozones according to its agglutinated foraminiferal content, in Abu Had and Duwi sections *(Figs. 2 and 3)* they are from base to top:

1. *Ammodiscus mangusi* Zone
2. *Trochammina undulosa* Zone
3. *Lituola difformis—taylorensis* Zone
4. *Ammobaculites khargensis* Zone

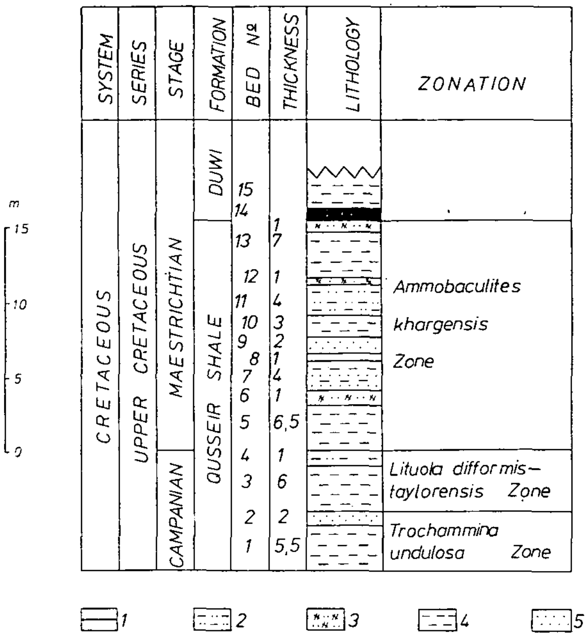

Fig. 2. Agglutinated foraminiferal zonation of Qusseir (variegated) shale at Gebel Abu Had section, Qena region
1. Phosphate. — *2.* Arenaceous shale. — *3.* Ferruginous sanstone. — *4.* Shale. — *5.* Sandstone.

1. *Ammodiscus mangusi* Zone

Occurrence: This zone is represented by the lowermost part of the Qusseir Shale of Duwi section, and not recorded in the Abu Had section.

Definition: The zone is defined by the first appearance and abundance of *Ammodiscus mangusi* (TAPPAN).

Description and faunal content: Lithologically, this zone (about 12 m in thickness) is composed mainly of pale grey shale and sandstone. The additional foraminiferal assemblage is as follows: *Glomospirella gaultina* (BERTHELIN), few specimens of *Ammodiscus glabratus* CUSHMAN ET WATERS, *Haplophragmoides gracilis* SAID ET KENAWY.

2. *Trochammina undulosa* Zone

Occurrence: It is represented by the lower part of the Qusseir Shales of Abu Had and Duwi sections.

Definition: The zone is defined by the first appearance and abundance of *Trocham-*

mina undulosa SCHIJFSMA and the absence of *Lituola difformis* LAMARCK and *L. taylorentis* CUSHMAN ET WATERS.

Description and faunal content: Lithologically this zone (about 7,5 m in thickness) is composed mainly of pale grey shales and sandstones and represents the lower part of the Qusseir Shales. The additional foraminiferal assemblage is as follows: *Trochammina borealis* KELLER, *Tr. ruthven-murrayi* CUSHMAN ET RENZ, *Tr. rainwateri* CUSHMAN ET APPLIN, *Tr. ribstonensis* WICKENDEN, *Tr. webbi* STELCK, *Tr. wickendeni* LOEBLICH, *Tr. gyroides* CUSHMAN ET WATERS and *Tr. texana* CUSHMAN ET WATERS.

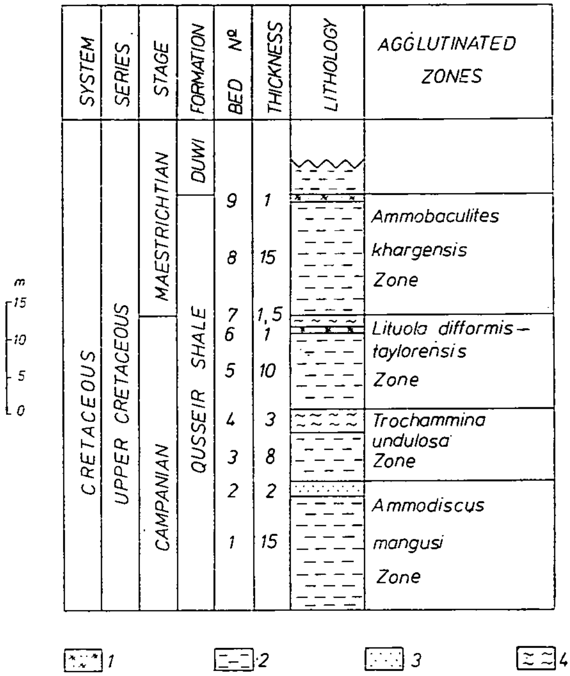

Fig. 3. Agglutinated foraminiferal zonation of the Qusseir (variegated) shale at Gebel Duwi, Qusseir district
1. Ferruginous sandstone. — *2.* Shale. — *3.* Sandstone. *4.* Marl.

3. *Lituola difformis—taylorensis* Zone

Occurrence: This zone represents the middle part of the Qusseir Shales of Abu Had and Duwi sections.

Definition: The zone is defined by the first appearance of *Lituola difformis* LAMARCK and *L. taylorensis* CUSHMAN ET WATERS which occurs in large numbers.

Description and faunal content: Lithologically, this zone is represented by shales and argillaceous shales. Other species were also recognized, such as: *Haplophragmoides glabra* CUSHMAN ET WATERS, *H. gracilis* SAID ET KENAWY, *H. rugosa* CUSHMAN ET WATERS, *H. sewellensis* OLSSON, *H. calculus* CUSHMAN ET WATERS, *Lituola obscura* BARNARD ET BANNER.

4. *Ammobaculites khargensis* Zone

Occurrence: It is represented in the upper part of the Qusseir Shales of Abu Had und Duwi sections.

Definition: The zone is distinguished by the first appearance of *Ammobaculites khargensis* NAKKADY ET TALAAT overlying the *Lituola difformis—taylorensis* Zone.

Description and faunal content: The zone (total thickness about 30,5 m) is mainly composed of shales, arenaceous shales, and argillaceous sandstone. Other faunal element met with are: *Ammobaculites colombiana* CUSHMAN ET HEDBERG, *A. stephensoni* CUSHMAN, *A. alexanderi* CUSHMAN, *A. advenus* CUSHMAN ET APPLIN, *A. agrestis* CUSHMAN ET APPLIN, *A. rowei* BANNER, *A. esnehensis* var. *nudus* NAKKADY, *Haplophragmium compressum* BEISSEL.

AGE ASSIGNMENT

The lower and the middle parts of the Qusseir Shales in the studied areas include the zones of *Ammodiscus mangusi,* the *Trochammina undulosa* and the *Lituola difformis—taylorensis*, respectively.

The characteristic species of these zones were firstly described from the Campanian sediments of France, USA, Canada and in other parts of Egypt. Therefore, the present authors incline to assigne a Campanian age to the lower and middle part of the Qusseir Shales.

The faunal assemblage of the *Ammobaculites khargensis* Zone is to correlate with similar ones in Egypt and other parts of the world, and it is referred to the Maestrichtian age.

SYSTEMATIC DESCRIPTION

Ordo: *Foraminifera* EICHWALD, 1830
Subordo: Textulariina DELAGE ET HEROUARD, 1896
Superfamily: *Ammodiscacea* REUSS, 1862
Family: Rzehakinidae CUSHMAN, 1933
Subfamily: Rzehakininae CUSHMAN, 1933
Genus: *Miliammina* HERON-ALLEN ET EARLAND, 1930

Miliammina awunensis TAPPAN

PLATE I, *Figs. 13—14*

Miliammina awunensis TAPPAN (1957, p. 210; Pl. 67, *Figs. 19—21*)

Remarks: This species is characterized by somewhat large test with thicker chambers, and with finely agglutinated wall and smoothly finished exterior. Length 0,23 mm, width 0,17 mm.

Occurrence: Miliammina awunensis was previously described from the Cretaceous Grandstand Formation (Turonian) in Northern Alaska. In the present study, it is recorded from the lower part of Qusseir Shales.

Miliammina bisobscura STELCK ET WALL

PLATE I, *Fig. 12;* PLATE V, *Fig. 3*

Miliammina bisobscura STELCK ET WALL (1954, p. 29; Pl. 1, *Figs. 1—2*)

Remarks: The species is chracterized by compressed subelliptical test, chambers in alternating cyclic arrangement, and simple aperture. Length 0,30 mm, width 0,17 mm.

Occurrence: This species was first described from the Kaskapaw Formation (Lower Turonian) in Canada. It occurs mainly in the lower part of the Qusseir Shales.

Family: Ammodiscidae REUSS, 1862
Subfamily: *Ammodiscinae* REUSS, 1862
Genus: *Ammodiscus* REUSS, 1862

Ammodiscus glabratus CUSHMAN ET JARVIS

PLATE I, *Figs. 10—11*

Ammodiscus glabratus CUSHMAN ET JARVIS (1928, p. 86; Pl. 12, *Fig. 6*)

Remarks: This species has a thin agglutinated wall with considerable amount of siliceous cement producing a smooth surface. The figured specimen measures 0,4 mm in diameter and 0,03 mm in thickness.

Occurrence: CUSHMAN nad JARVIS first described this species from the Lizard Springs in Trinidad (Late Meastrichtian). It occurs mainly in the upper part of the Qusseir Shales.

Ammodiscus mangusi (TAPPAN)

PLATE I, *Figs. 7—9*

Involutina mangusi TAPPAN (1957, p. 203; Pl. 65, *Figs. 13—14*)

Remarks: Test free, discoidal, consisting of proloculus and long, undivided, planispiral, evolute second chamber, which is relatively thick and forms only a few whorls. Specimens commonly compressed in preservation. Wall finely to moderately coarsely agglutinated; aperture at the open end of the tubular chamber. It is characterized by a more evenly planispiral, and it is not so irregularly coiled in the early stages as *A. gaultinus*.

Occurrence: This species was found in the Topaguruk and Grandstand Formation. It occurs mainly in the lower part of the Qusseir Shales, too.

Genus: *Glomospira* RZEHAK, 1888

Glomospira irregularis (GRZYBOWSKI)

PLATE I, *Fig. 2*

Ammodiscus irregularis GRZYBOWSKI (1898, p. 285; Pl. 11. *Figs. 2—3*). — *Glomospira irregularis* (GRZYBOWSKI): GLAESSNER (1937, p. 359; Pl. 1, *Fig. 7;* POKORNÝ (1958, pp. 11—12; *Text-fig. 3*).

Remarks: This species is characterized by rough surface, highly irregular coiling of the tubular chamber. Wall consists of fine-grained quartz with siliceous cement. Diameter 0,4 mm to 0,9 mm.

Occurrence: GRZYBOWSKI described this species from the Upper Cretaceous of the Polish Carpathians (beds with *Inoceramus*). It was found by us in the Gebel Duwi section, in the *Ammodiscus mangusi* Zone. Age: Campanian.

Glomospira serpens (GRZYBOWSKI)

PLATE I, *Figs. 3—4:* PLATE IV, *Figs. 11—12*

Ammodiscus serpens GRZYBOWSKI (1898, p. 285; Pl. 10, *Figs. 31—33*). — *Glomospira serpens* (GRZYBOWSKI): GEROCH (1962, p. 47; Pl. 4, *Fig. 13*).

Remarks: The test of this species is smooth, its tubular chamber elliptically coiled (2—3 coils). Wall consists of fine quartz grains with siliceous cement. Diameter 0,8 mm to 1 mm.

Occurrence: It was first described from the Upper Cretaceous of the Polish Carpathians (beds with *Inoceramus*). In our sections, it was identified from the *Ammodiscus mangusi* Zone. — Age: Campanian.

Genus: *Glomospirella* PLUMER, 1945
Glomospirella gaultina (BERTHELIN)

PLATE I, *Figs. 5—6*

Ammodiscus gaultinus BERTHELIN (1880, p. 19; Pl. 1, *Fig. 3a—b*). — LOEBLICH AND TAPPAN 1964, p. 95; Pl. 14, *Fig. a—c*). — FRIZZEL (1954, p. 58; Pl. 4, *Fig. 17a—c*). — *Glomospirella gaultina* (BERTHELIN): TAPPAN (1962, p. 130; Pl. 29. *Figs. 17—20*).

Remarks: This species is characterized by shell of small size (diameter 0,24—0,30 mm), and rounded outline. The tubular chamber coiled in 5 coils. Spiral suture slightly depressed. Wall agglutinated, fine-grained, and 0,012 mm in thickness.

Occurrence: It was described by BERTHELIN (1880) from the Cretaceous of France. In the present study, it is recorded from the Qusseir Shales of G. Duwi (lower part). — Age: Campanian.

Superfamily: *Lituolacea* BLAINVILLE, 1825
Family: Hormosinidae HAECKEL, 1894
Subfamily: Hormosininae HAECKEL, 1894
Genus: *Proteonina* WILLIAMSON, 1858

Proteonina complanata FRANKE

PLATE I, *Fig. 1*

Proteonina complanata FRANKE (1914, p. 431; Pl. 27, *Figs. 1—2*).

Remarks: It is characterized by a flattened test and siliceous agglutinated wall consisting of finely cemented quartz grains, ranged in size from 0,03 to 0,005 mm, with a large amount of cement. Lenght 0,50 mm, breadth 0,33 mm, thickness 0,03 mm.

Occurrence: FRANKE (1914) recorded this species from the Upper Cretaceous (Campanian) of Germany. The present writers identified it from the Qusseir Shales.

Family: Lituolidae BLAINVILLE, 1825
Subfamily: Haplophragmoidinae MAYNC, 1952
Genus: *Haplophragmoides* CUSHMAN, 1910

Haplophragmoides calculus CUSHMAN ET WATERS

PLATE I, *Figs. 17—18*; PLATE IV, *Fig. 15;* PLATE VII, *Fig. 2*

Haplophragmoides calculus CUSHMAN ET WATERS (1927, p. 83; Pl. 10, *Fig. 5*). — FRIZZEL (1954, p. 59; Pl. 1, *Figs. 26a—b*).

Remarks: The species is characterized by a simple wall, increasing in thickness from 0,02 to 0,09 mm, and composed of quartz grains ranging in size from 0,01 to 0,08 mm. Length 0,79 mm; thickness 0,17 mm.

Occurrence: It was first described from the Navarro Formation (Maestrichtian) in Texas. It occurs in the upper Qusseir Shales, too.

Haplophragmoides glabra CUSHMAN ET WATERS

PLATE II, *Fig. 1;* PLATE IV. *Fig. 14*

Haplophragmoides glabra CUSHMAN ET WATERS (1927, p. 83; Pl. 10, *Fig. 6*).

Remarks: The species is characterized by a finely agglutinated wall, gradually increased in thickness from 0,02 to 0,03 mm, and composed of quartz grains ranged in size from 0,005 to 0,01 mm. Length 0,50 mm, width 0,43 mm, thickness 0,17 mm.

Occurrence: It was first identified from the Navarro Formation (Maestrichtian) in Texas. It occurs in the upper Qusseir Shales, too.

Haplophragmoides glomeratoformis ZASPYELOVA

PLATE V, *Fig. 1*

Haplophragmium glomeratum (BRADY): CHAPMAN (1892, p. 321; Pl. 5, *Fig. 8*); fide ELLIS AND MESSINA (1940). — *Haplophragmoides glomeratoformis* ZASPYELOVA (1948, p. 197; Pl. 1, *Figs. 4a—b*).

Remarks: Test planispiral, rounded. Peripheral margin rounded and lobate. In the final whorl there are four five inflated chambers varying in shape from irregularly oval to spherical. Sutures depressed, straight or very weakly curved. Aperture indistinct. Wall moderately grained.

Occurrence: This species was recorded by ZASPYELOVA (1948) from the Upper Cretaceous of the West-Siberian Lowland. In Egypt, it was found in the *Lituola difformis—taylorensis* Zone of the Qusseir Shales in the Gebel Abu Had and Duwi sections.

Haplophragmoides gracilis SAID ET KENAWY

PLATE *I, Fig. 19*

Haplophragmoides gracilis SAID ET KENAWY (1957, p. 78; Pl. 13, *Fig. 1*).

Remarks: This species is characterized by a simple wall, finely agglutinated, gradually increased in thickness from 0,01 to 0,02 mm, and composed of quartz grains ranging in size from 0,005 to 0,01 mm, with a considerable amount of ferruginous material and little amount of siliceaous cement. Diameter 0,33 mm; thickness 0,03 mm.

Occurrence: The species was previously identified from the Turonian succession in Abu Roash area. In the present study it is recorded from the lower part of the Qusseir Shales.

Haplophragmoides kirki WICKENDEN

PLATE II, *Fig. 5;* PLATE V, *Fig. 5;* PLATE VI, *Fig. 4*

Haplophragmoides kirki WICKENDEN (1932, p. 85; Pl. 1, *Fig. 1*).

Remarks: The species is characterized by its simple wall, about 0,04 mm in thickness, and composed of quartz grains ranging in size from 0,004 to 0,04 mm Diameter 0,4 mm; thickness 0,3 mm.

Occurrence: This species was firstly recorded from the Upper Cretaceous Bearpaw Shale in Canada. It occurs in the Qusseir Shales, too.

Haplophragmoides rota NAUSS

PLATE I, *Figs. 15—16;* PLATE VI, *Fig. 3*

Haplophragmoides rota NAUSS (1947, p. 339; Pl. 49, *Figs. 1, 3*).

Remarks: The species is characterized by a simple wall, coarsely agglutinated, increasing in thickness from 0,03 to 0,07 mm and composed of quartz grains ranging in size from 0,01 to 0,06 mm, with considerable amount of siliceous cement. Diameter 0,26 mm; thickness 0,20 mm.

Occurrence: The species was firstly described from the Late Cretaceous sediment in Alberta, Canada. It occurs mainly in upper part of the Qusseir Shales.

Haplophragmoides rugosa CUSHMAN ET WATERS

PLATE IV, *Fig. 13*

Haplophragmoides rugosa CUSHMAN ET WATERS (1927, p. 83; Pl. 19, *Fig. 4*).

Remarks: Test close-coiled, planispiral, deeply umbilicate; periphery broadly rounded. Sutures slightly depressed radially. Wall coarsely agglutinated.

Occurrence: This species was described by Cushman and Waters from the Navarro group of Texas (Maestrichtian. We found it in the *Lituola difformis—taylorensis* Zone of the Qusseir Shales in the Abu Had and Duwi sections.

Haplophragmoides sewellensis OLSSON

PLATE II, *Fig. 3*

Haplophragmoides sewellensis OLSSON (1960, p. 5; Pl. 1, *Figs. 1—2*).

Remarks: This species is characterized by its small size and finely agglutinated wall. Diameter 0,17 mm; thickness 0,07 mm.

Occurrence: The species was previously reported from the Late Maetrichtian sediments of New Jersey. It occurs in the upper part of the Qusseir Shales.

Haplophragmoides spiritensis STELCK ET WALL

PLATE II, *Fig. 2;* PLATE VI; *Fig. 5*

Haplophragmoides spiritensis STELCK ET WALL (1954, p. 28; Pl. 2, *Figs. 7—9*).

Remarks: It is characterized by a simple wall, finely agglutinated, increasing in thickness from 0,01 to 0,02 mm, and composed of quarts grains ranging in size from 0,005 to 0,02 mm, with considerable amount of ferrugimous material and siliceous cement producing a smoothly finished surface. Diameter 0,43 mm; thickness 0,10 mm.

Occurrence: The species was previously described from the Kaskapau Formation (Lower Turonian) in Canada. It occurs in the lower part of the Qusseir Shales at Gebel Abu Had.

Genus: *Cribrostomoides* CUSHMAN, 1910

Cribrostomoides cretacea CUSHMAN ET GOUDKOFF

PLATE II, *Fig. 10*

Cribrostomoides cretacea CUSHMAN ET GOUDKOFF (1944, p. 54; Pl. 9, *Fig. 4*).

Remarks: The species is characterized by its finely agglutinated wall and smoothly finished exterior. Length 0,69 mm, width 0,4 mm, thickness 0,23 mm.

Occurrence: It was firstly recorded from the Upper Cretaceous beds in California. It occurs in the upper Qusseir Shales of the Abu Had section, too.

Subfamily: Lituolinae BLAINVILLE
Genus: *Lituola* LAMARCK, 1804

Lituola difformis LAMARCK

PLATE II, *Fig. 14*

Lituola difformis LAMARCK (1804, 5, pp. 242—245; Pl. 14). — MAYNC (1952, pp. 37, 38, 47; Pl. 10. *Figs. 1—6*).

Remarks: The species is characterized by a simple wall, gradually increasing in thickness from 0,02 to 0,05 mm, and composed of quartz grains ranging in size from 0,01 to 0,05 mm. Length 0,6 mm, width 0,46 mm, thickness 0,27 mm.

Occurrence: It was firstly described from the Meduon beds (Campanian) in France. It occurs in the Qusseir Shales of both Abu Had and Duwi.

Lituola taylorensis CUSHMAN ET WATERS

PLATE II, *Fig. 16*

Lituola taylorensis CUSHMAN ET WATERS (1929, p. 66; Pl. 10, *Fig. 7*).

Remarks: This species is characterized by a simple wall, coarsely arenaceous, with large amount of cement. Length 0,83 mm, width 0,50 mm, thickness 0,14 mm.

Occurrence: It was firstly described from the upper Taylor marl (Campanian) in Texas. It occurs in the Qusseir Shales of both Abu Had and Duwi.

Lituola obscura BARNARD ET BANNER

PLATE II, *Fig. 4*

Lituola obscrura BARNARD ET BANNER (1953, p. 181; Pl. 7, *Fig. 7*).

Remarks: It is characterized by a large size, coarsely agglutinated simple wall with small amount of cement. Length 0,9 mm, width 0,65 mm, thickness 0,17 mm.

Occurrence: First record from the Upper Senonian—Lower Maestrichtian sediments of Norfolk, England. It was found in the upper part of the Qusseir Shales of Abu Had section.

Genus *Ammobaculites* CUSHMAN, 1910

Ammobaculites advenus CUSHMAN ET APPLIN

PLATE II, *Fig. 9;* PLATE VI, *Fig. 2*

Ammobaculites advenus CUSHMAN ET APPLIN (1947, p. 53; Pl. 13, *Fig. 1*)

Remarks: The species is characterized by its simple wall coarsely agglutinated, composed of quartz grains ranging in size from 0,06 to 0,01 mm, with little amount of siliceous cement. Length 0,69 mm; width 0,56 mm; thickness 0,10 mm.

Occurrence: Ammobaculites advenus was firstly described from the Upper Cretaceous sediments in Texas. In the present study, this species occurs aboundantly in the Qusseir shales in Gebel *D*uwi.

Ammobaculites agrestis CUSHMAN ET APPLIN

PLATE II, *Fig. 15;* PLATE VII, *Fig. 1*

Ammobaculites agrestis CUSHMAN ET APPLIN (1947, p. 53; Pl. 13, *Figs. 2—3*) — FRIZZELL (1954, p. 61; Pl. 2, *Figs. 10a—b*)

Remarks: This species is characterized by a simple wall, decreasing in thickness from 0,05 to 0,03 mm, and composed of quartz grains ranging in size from 0,04 to 0,2 mm. Length 0,56 mm; width 0,39 mm; and thickness 0,13 mm.

Occurrence: Ammobaculites agrestis was previously reported from the Campanian beds in Texas. It occurs mainly in the Qusseir shales of Abu Had section.

Ammobaculites alexanderi CUSHMAN

PLATE III, *Fig. 1*

Ammobaculites alexanderi CUSHMAN (1933, p. 51; Pl. 5. *Fig. 5*)

Remarks: This species is characterized by its elongate test and coarsely agglutinated wall. Length 0,43 mm, width 0,20 mm, and thickness 0,15 mm.

Occurrence: This species was firstly recorded from the Campanian in Texas. It occurs commonly in the Qusseir shales of Gebel Duwi.

Ammobaculites colombiana CUSHMAN ET HEDBERG

PLATE III, *Fig. 3;* PLATE VII, *Fig. 4*

Ammobaculites colombiana CUSHMAN ET HEDBERG (1930, p. 68; Pl. 9, *Fig. 4*)

Remarks: Ammobaculites colombiana is characterized by a simple arenaceous agglutinated wall, about 0,02 mm in thickness and composed of quartz grains ranging in size from 0,05 to 0,01 mm, with considerable amount of siliceous cement. Length 0,36 mm; width 0,30 mm.

Occurrence: This species was firstly described from the Upper Cretaceous beds in Colombia. It is identified mainly from the Qusseir shales of Gebel Duwi.

Ammobaculites esnehensis var. *nudus* NAKKADY

PLATE II, *Fig. 6*

Ammobaculites esnehensis var. *nudus* NAKKADY (1949, pp. 221, 234, 240; 1950, p. 683; Pl. 83, *Fig. 3*)

Remarks: This species is characterized by its small size, finely agglutinated wall with a considerable amount of cement resulting a smoothly finished surface. Length 0,50 mm; diameter of coiled portion 0,33 mm.

Occurrence: It was previously reported from the Dakhla Shales of Sinai. The species occurs also in the Qusseir shales of Gebel Duwi.

Ammobaculites khargensis NAKKADY ET TALAAT

PLATE III, *Fig. 14;* PLATE V, *Fig. 4*

Ammobaculites khargensis NAKKADY ET TALAAT (1959, p. 456; Pl. 6, *Figs. 1a—b, 2a—b*)

Remarks: The species is characterized by its large size and more coarsely agglutinated wall with considerable amount of siliceous cement. Length 1,5 mm; width 1,2 mm; thickness 0,21 mm.

Occurrence: NAKKADY ET TALAAT (1959) indetified this species from the *Exogyra* bed and Kharga Shale member in Gebel Umm el Ghanayem. It occurs only in the upper levels of the Qusseir shales in Abu Had and Duwi sections.

Ammobaculites stephensoni CUSHMAN

PLATE II, *Fig. 8*

Ammobaculites stephensoni CUSHMAN (1933, p. 49; Pl. 5, *Fig. 2*) — FRIZZELL (1954, p. 62; Pl. 2, *Figs. 26a—b*)

Remarks: The species is characterized by coarsely arenaceous wall, increasing in thickness from 0,02 to 0,08 mm; with a little amount of ferruginous materials. Length 0,79 mm; width 0,59 mm; thickness 0,17 mm.

Occurrence: It was first drecribed from the Taylor marl (Campanian) in Texas It occurs abundantly in the upper parts in the Qusseir shales in Abu Had section, in the *Ammobaculites khargensis* Zone.

Ammobaculites rowei BANNER

PLATE III, *Fig. 2*

Ammobaculites rowei BANNER (1953, p. 180; Pl. 7, *Fig. 6*).

Remarks: The uniserial portion is sometimes irregularly curved. Wall agglutinated, thick, rugose, composed of fine quartz grains with siliceous cement. Length 0,68 mm; width 0,56 mm; thickness 0,15 mm.

Occurrence: The species was recorded from the Lower Coniacian sediments near Seaford Head, Sussex, England. In the present study, this species was identified from the *Ammobaculites khargensis* Zone of the Abu Had and Duwi sections.

Ammobaculites comprimatus CUSHMAN ET APPLIN

PLATE II, *Fig. 7*

Ammobaculites comprimatus CUSHMAN ET APPLIN (1946, p. 73; Pl. 13, *Fig. 3*)

Remarks: Chambers increasing in size as added. Sutures are distinct. Wall agglutinated, finegrained, producing a smooth surface. Length 0,65 mm; width 0,50 mm; thickness 0,18 mm.

Occurrence: This species was firstly described from the Upper Cretaceous and upper part of the Woodbine Formation (Cenomanian) in Texas. It was rarely recorded from the upper level of the Qusseir shales of Abu Had and Duwi sections *(Ammobaculites khargensis* Zone).

Genus *Ammobaculoides* PLUMMER, 1932

Ammobaculoides plummerae LOEBLICH

PLATE II, *Fig. 13*

Ammobaculoides plummerae LOEBLICH (1946, p. 137; Pl. 22, *Figs. 10—12*)

Remarks: The species is characterized by its simple agglutinated wall, about 0,03 mm in thickness, with large amount of siliceous cement. Length 0,60 mm; width 0,25 mm; thickness 0,10 mm.

Occurrence: LOEBLICH (1946) firstly recorded this species from the Upper Cretaceous sediments in Texas. In the Eastern Desert, this species occurs in the *Ammobaculites khargensis* Zone of the Abu Had and Duwi sections.

Genus *Haplophragmium* REUSS, 1860

Haplophragmium compressum BEISSEL

PLATE II, *Fig. 11—12;* PLATE V, *Fig. 2*

Haplophragmoides compressum BEISSEL (1886, p. 138) — BEISSEL (1891, pp. 16—17; Pl. 4, *Figs. 11—23*)

Remarks: This species is characterized by a small and highly compressed test. Length 0,36 mm; diameter of coiled portion 0,17 mm.

Occurrence: Haplophragmium compressum was first described from Upper Cretaceous beds in Germany. It occurs mainly in the *Ammobaculites khargensis* zone (Maestrichtian).

Family: Textulariidae EHRENBERG, 1839
Subfamily: Spiroplectammininae CUSHMAN, 1927
Genus: *Spiroplectammina* CUSHMAN, 1927

Spiroplectammina bentonensis CARMAN

PLATE III, *Fig. 5—10;* PLATE VI, *Fig. 1*

Spiroplectammina bentonensis CARMAN (1929, p. 311; 34, *Figs. 8—9*)

Remarks: This species is characterized by slightly oblique sutures and finely agglutinated wall with much cement, producing smoothly finished surface. Length 0,33 mm; width 0,13 mm; thickness 0,07 mm.

Occurrence: The species was first described from the Upper Cretaceous Benton Shale (USA). This species occurs abundantly in the upper part of the Qusseir Shales (*Ammobaculites khargensis* zone) of Abu Had and Duwi sections.

Spiroplectammina tenuis GAUGER

PLATE III, *Fig. 11*

Spiroplectammina dentata (ALTH) var. *tenuis* GAUGER (1953, p. 59; Pl. 6, *Figs. 1, 1a, 2*)

Remarks: This species is characterized by limbate sutures, relatively compressed chambers extended into short processes, and finely agglutinated wall with much cement and smoothly finished exterior. Length 0,30 mm; width 0,13 mm; thickness: 0,03 mm.

Occurrence: It was firstly described from the. Upper Cretaceous beds of USA. It occurs mainly in the *Lituola difformis—taylorensis* Zone (Campanian) in the Abu Had and Duwi sections .

Family: Trochamminidae SCHWAGER, 1877
Subfamily: Trochammininae SCHWAGER, 1877
Genus: *Trochammina* PARKER ET JONES

Trochammina albertensis WICKENDEN

PLATE III, *Figs. 17—18*

Trochammina albertensis WICKENDEN (1932, p. 90; Pl. 1, *Figs. 9a—b*)

Remarks: This species is characterized by its finely agglutinated wall with much cement. Diameter 0,36 mm; thickness 0,07 mm.

Occurrence: WICKENDEN first recorded this species from the Upper Cretaceous Bearpaw Shale (Canada). In the studied sections it occurs in the *Lituola difformis—taylorensis* zone.

Trochammina altiformis CUSHMAN ET RENZ

PLATE IV, *Fig. 1—2*

Trochammina globigeriniformis PARKER ET JONES var. *altiformis* CUSHMAN ET RENZ (1946 p. 24; Pl. 3, *Figs. 7—11*)

Remarks: This species is characterized by a finely agglutinated wall with considerable amount of cement. Diameter 0,30 to 0,20 mm.

Occurrence: It was privously described from the Lizard Springs marl (Late Maestrichtian—Danian) in Trinidad. The species occurs mainly in the upper part of the *Ammobaculites khargensis* Zone in the Duwi and Abu Had sections.

Trochammina texana CUSHMAN ET WATERS

PLATE III, *Figs. 12—13*

Trochammina texana CUSHMAN ET WATESR (1927, *2*, p. 85; Pl. 11, *Figs. 8*)

Remarks: This species is characterized by very finely agglutinated wall and smoothly finished exterior. Diameter 0,42—0,45 mm.

Occurrence: Trochammina texana was firstly described from the Navarro Formation (Maestrichtian) in Texas. In Eastern Desert, this species occurs in the *Ammobaculites khargensis* (Maestrichtian) zone of the Quesseir shales in the Abu Had and Duwi sections.

Trochammina borealis KELLER

PLATE IV, *Figs. 5—6*

Trochammina borealis KELLER (1935, p. 38; Pl. 2, *Fig. 11a*)

Remarks: Trochammina borealis in characterized by the relative height of its spire, which is deviating from its type form; wall finely agglutinated with much siliceous cement. Diameter 0,35 to 0,40 mm.

Occurrence: This species was firstly described from the Upper Cretaceous white chalk of northern edge of the Dnjepr—Donetz Basin (USSR). It occurs in the *Tro-*

chammina undulosa Zone (Campanian) in the Qusseir Shales of the Abu Had and Duwi Sections.

Trochammina gyroides CUSHMAN ET WATERS

PLATE III, *Figs. 19—20*

Trochammina gyroides CUSHMAN ET WATERS (1927, p. 84; Pl. 10, *Fig. 8*)

Remarks: This species is characterized by subacute periphery, finely agglutinated wall, which is composed of fine quartz grains (0,01—0,02 mm in size) and siliceous cement. Diameter 0,28 to 0,32 mm.

Occurrence: Trochammina gyroides was first described from the Upper Cretaceous in Texas. This species identified from the *Trochammina undulosa* Zone (Campanian) in Gebel Abu Had section.

Trochammina rainwateri CUSHMAN ET APPLIN

PLATE III, *Fig. 21*

Trochammina rainwateri CUSHMAN ET APPLIN (1946 p. 75; Pl. 3, *Fig. 9*)

Remarks: The species is characterized by gradually and regularly increasing in size of chambers, wall finely agglutinated composed from fine quartz grains and ferruginous cement. Diameter 0,35 to 0,38 mm.

Occurrence: The species was firstly described from the upper part of the Woodbine Formation (Upper Cretaceous), Texas. It occurs in the *Trochammina undulosa* Zone (Campanian) of Abu Had and Duwi sections.

Trochammina ribstonensis WICKENDEN

PLATE IV, *Figs. 9—10*

Trochammina ribstonensis WICKENDEN (1932, p. 90; Pl. 1, *Figs. 12a—c*)

Remarks: Test very small with globular chambers and slightly curved, nearly radiate sutures; wall finely agglutinated, thin, composed of fine quartz grains with siliceous cement. Diameter 0,18 to 0,24 mm.

Occurrence: This species was first recorded from the Upper Cretaceous sediments, Alberta, Canada. It was recorded in the *Trochammina undulosa* Zone in the Qusseir Shales of Abu Had and Duwi sections.

Trochammina ruthven-murrayi CUSHMAN ET RENZ

PLATE IV, *Figs. 7—8*

Trochammina ruthven-murrayi CUSHMAN ET RENZ (1946, p. 24; Pl. 3, *Fig. 13*)

Remarks: The species somewhat resembles *Trochammina ribstonesis* WICKENDEN, but it much larger and more conical, the chambers at the dorsal side are more elongate and narrow, wall composed of fine-grained quartz (0,01—0,03 mm in size) with ferruginous cement.

Occurrence: It was first described from the Lizard Springs marls (USA). A rare number of this species was found in the *Trochammina undulosa* Zone (Campanian) in the Abu Had section.

Trochammina undulosa SCHIJFSMA

PLATE IV, *Figs. 3—4*

Trochammina undulosa SCHIJFSMA (1946, p. 39; Pl. 1, *Fig. 14*)

Remarks: The dorsal side is smooth and slightly convex, the periphery subacute, sutures curved backward, wall finely agglutinated, composed of fine grains of quartz with much siliceous cement producing a smooth surface. Diameter 0,32 to 0,35 mm.

Occurrence: SCHIJFSMA described this species from the Upper Cretaceous (Campanian) sediments in the Netherlands. This species occurs abundantly in the lower part of Qusseir shales in Abu Had section and somewhat higher in the Duwi section.

Trochammina webbi STELCK ET WALL

PLATE III, *Figs. 22—23*; PLATE VI, *Fig. 5*

Trochammina webbi STELCK ET WALL (1954, p. 33, pl. 2, *Fig. 11*)

Remarks: Test composed and slightly inflattened with lobate periphery, chambers gradually enlarging in size and subglobular in form, wall finely agglutinated with much quantity of cement.

Occurrence: This species was firstly described from the middle part of Kaskapau Formation (Upper Cretaceous), Alberta, Canada. It abundantly occurs in the most lower prat of the Qusseir shales (*Trochammina undulosa* Zone; Campanian) in the Abu Had and Duwi sections.

Trochammina wickendeni LOEBLICH

PLATE III, *Figs. 15—16*

Trochammina wickendeni LOEBLICH (1946, p. 138; Pl. 22, *Fig. 17*)

Remarks: This species is similar in size to *Trochammina albertensis* WICKENDEN from the Bearpaw shales of Canada, but it is not nearly so conical, as that. It has depressed sutures, few chambers and sharper periphery. Diameter 0,34 to 0,33 mm; thickness 0,06—0,07 mm.

Occurrence: Trochammina wickendeni was first recorded from the Upper Cretaceous Papper Formation, Oklahoma. It was found in the *Trochammina undulosa* Zone (Campanian) of the Abu Had and Duwi sections.

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EXPLANATION OF THE PLATES I—VII

Plate I

1. *Proteonina complanata* Franke (40x)
2. *Glomospira irregularis* (Grzybowski) (40x)

3—4. *Glomospira serpens* (Grzybowsky) (40x)
5—6. *Glomospirella gaultina* (Berthelin) (40x)
7—9. *Ammodiscus mangusi* (Tappan) (40x)
10—11. *Ammodiscus glabratus* Cushman et Jarvis (50x)
12. *Miliammina bisobscura* Stelck et Wall (50x)
13—14. *Miliammina awunensis* Tappan (100x)
15—16. *Haplophragmoides rota* Nauss (30x)
17—18. *Haplophragmoides calculus* Cushman et Waters (60x)
19. *Haplophragmoides gracilis* Said et Kenawy (50x)

Plate II

1. *Haplophragmoides glabra* Cushman et Waters (36x)
2. *Haplophragmoides spiritensis* Stelck et Wall (50x)
3. *Haplophragmoides sewellensis* Olsson (50x)
4. *Haplophragmoides rugosa* Cushman et Waters (50x)
5. *Haplophragmoides kirki* Wickenden (40x)
6. *Ammobaculites esnehensis* var. *nudus* Nakkady (30x)
7. *Ammobaculites comprimatus* Cushman et Applin (50x)
8. *Ammobaculites stephensoni* Cushman (50x)
9. *Ammobaculites advenus* Cushman et Applin (30x)
10. *Cribrostomoides cretacea* Cushman et Goudkoff (50x)

11—12. *Haplophragmium compressum* Beissel (50x)
13. *Ammobaculoides plummerae* Loeblich (30x)
14. *Lituola difformis* Lamarck (30x)
15. *Ammobaculites agrestis* Cushman et Applin (30x)
16. *Lituola taylorensis* Cushman et Waters (30x)

Plate III

1. *Ammobaculites alexanderi* Cushman (50x)
2. *Ammobaculites rowei* Banner (50x)
3. *Ammobaculites colombiana* Cushman et Hedberg (30x)
4. *Lituola obscura* Barnard et Banner (30x)

5—10. *Spiroplectammina bentonensis* Carman (100x)
11. *Spiroplectammina tenuis* Gauger (100x)
12—13. *Trochammina texana* Cushman et Waters (30x)
14. *Ammobaculites khargensis* Nakkady et Talaat (50x)
15—16. *Trochammina wickendeni* Loeblich (50x)
17—18. *Trochammina albertensis* Wickenden (80x)
19—20. *Trochammina gyroides* Cushman et Waters (50x)
21. *Trochammina rainwateri* Cushman et Applin (50x)
22—23. *Trochammina webbi* Stelck et Wall (50x)

Plate IV

1—2. *Trochammina altiformis* Cushman et Renz (50x)
3—4. *Trochammina undulosa* Schijfsma (50x)
5—6. *Trochammina borealis* Keller (50x)
7—8. *Trochammina ruthven-murrayi* Cushman et Renz (50x)
9—10. *Trochammina ribstonensis* Wickenden (50x)
11—12. *Glomospira serpens* (Grzybowski) (50x)
13. *Haplophragmoides rugosa* Cushman et Waters (60x)
14. *Haplophragmoides glabra* Cushman et Waters (120x)
15. *Haplophragmoides calculus* Cushman et Waters (80x)

Plate V

1. *Haplophragmoides glomeratoformis* Zaspyelova (100x)
2. *Haplophragmium compressum* Beissel (200x)
3. *Miliammina bisobscura* Stelck et Wall (225x)
4. *Ammobaculites khargensis* Nakkady et Talaat (60x)
5. *Haplophragmoides kirki* Wickenden (160x)

Plate VI

1. *Spiroplectammina bentonensis* Carman (200x)
2. *Ammobaculites advenus* Cushman et Applin — Equatorial section (100x)
3. *Haplophragmoides rota* Nauss — Equatorial section (100x)
4. *Haplophragmoides kirki* Wickenden — Equatorial section (200x)
5. *Haplophragmoides spiritensis* Stelck et Wall — Equatorial section (140x)

Plate VII

1. *Ammobaculites agrestis* Cushman et Applin — Equatorial section (100x)
2. *Haplophragmoides calculus* Cushman et Waters — Eqatorial section (200x)
3. *Trochammina webbi* Stelck et Wall — Equatorial section; 2N (100x)
4. *Ammobaculites colombiana* Cushman et Hedberg — Equatorial section (140x)

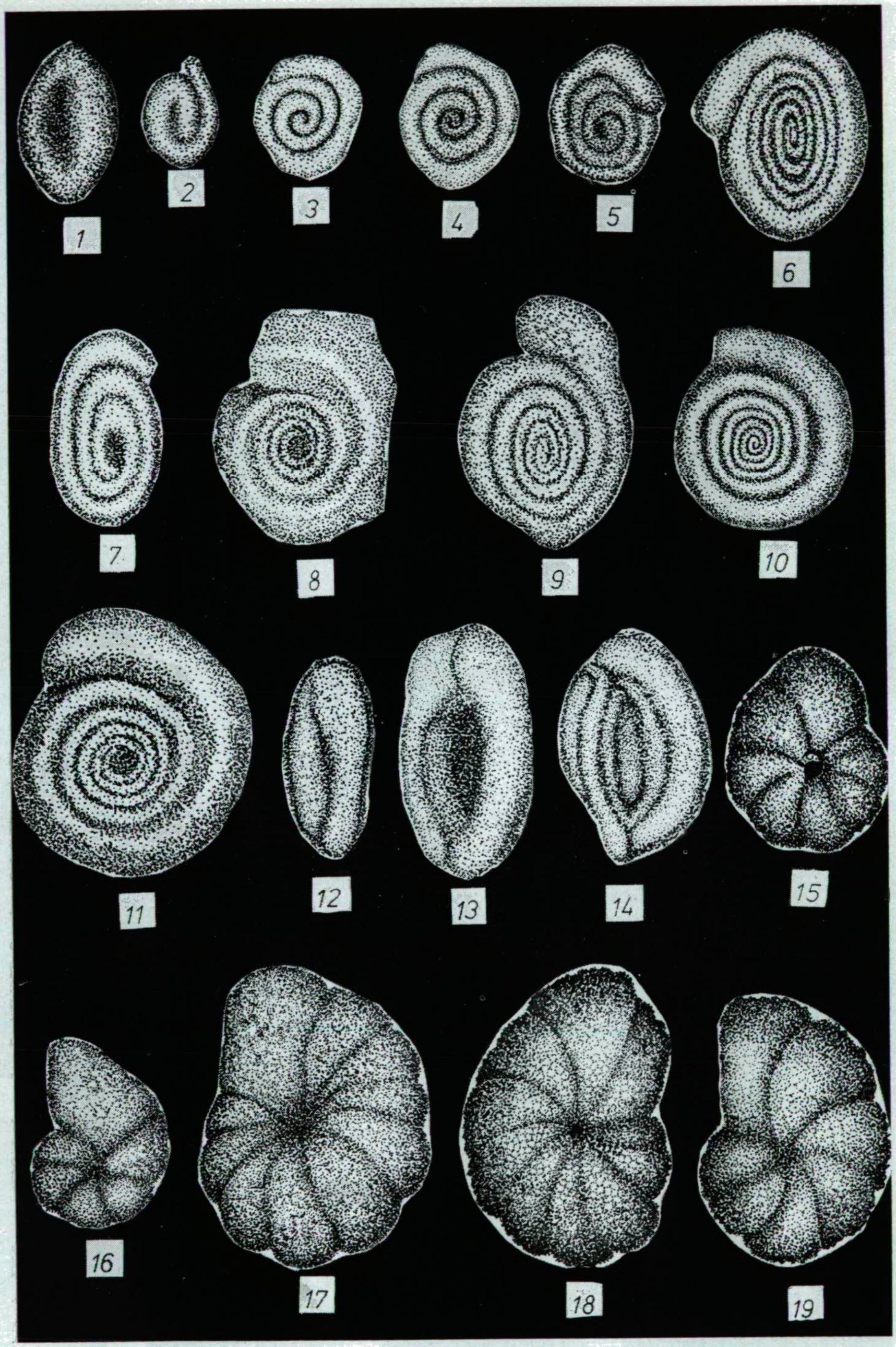
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PLATE II

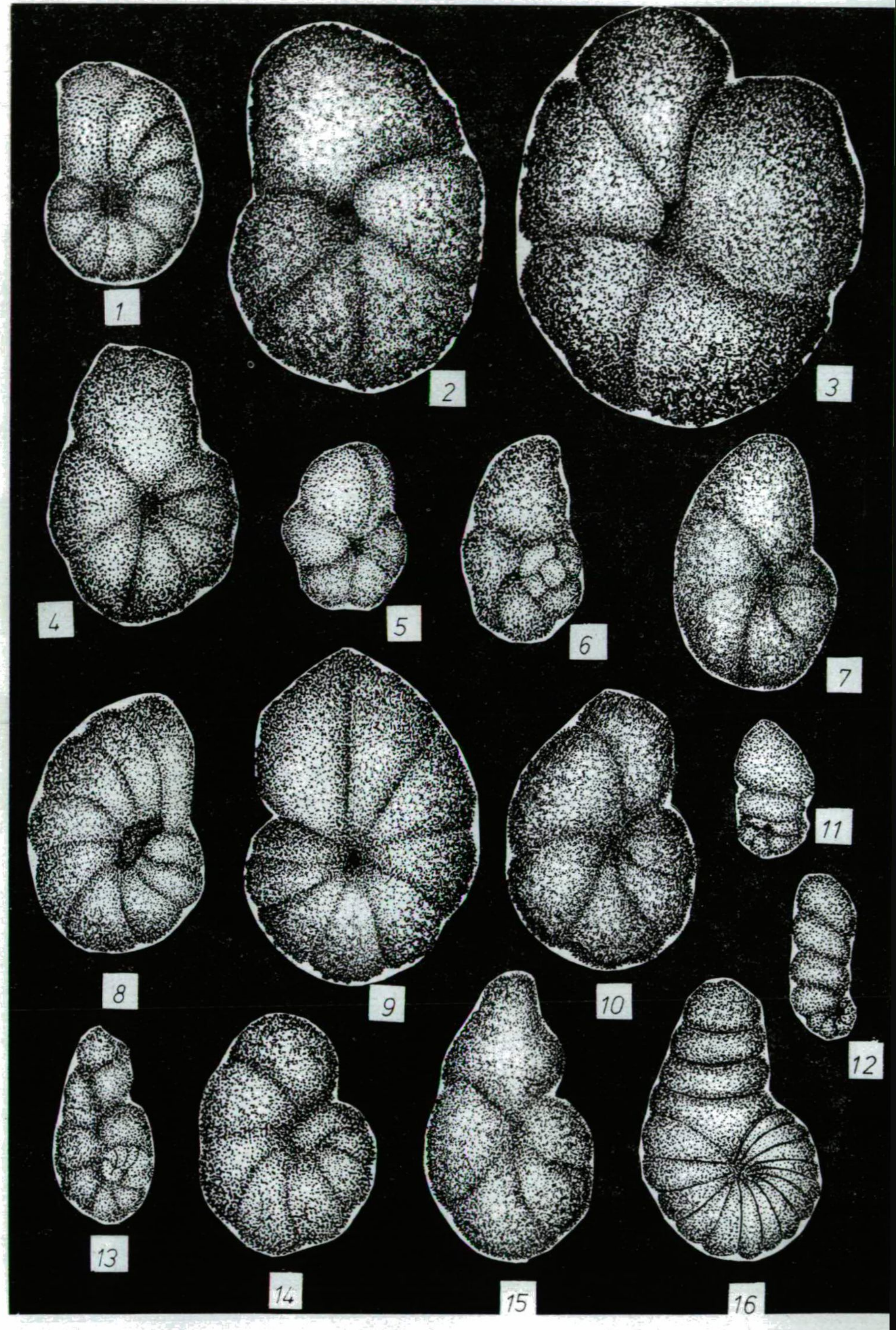
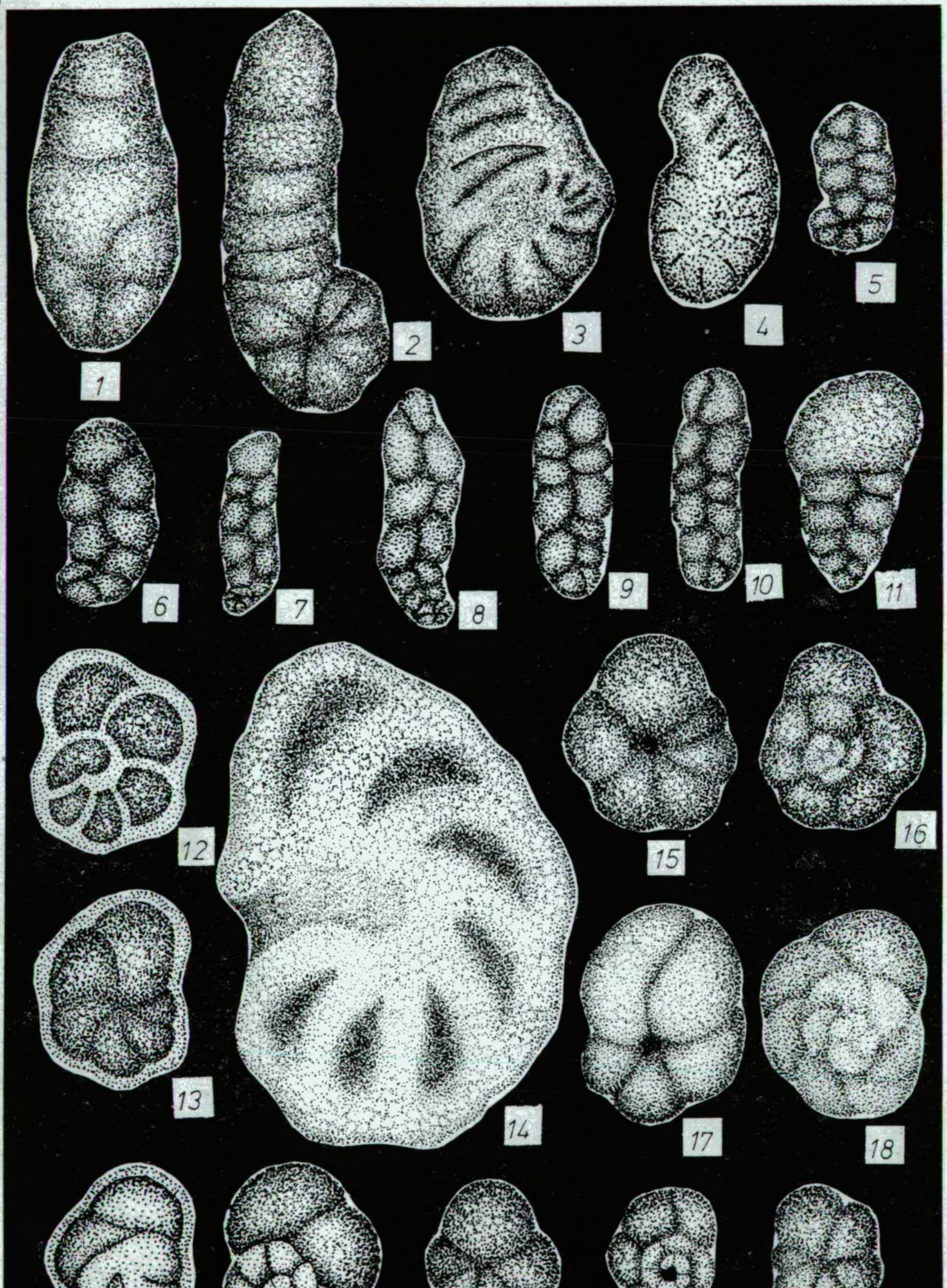
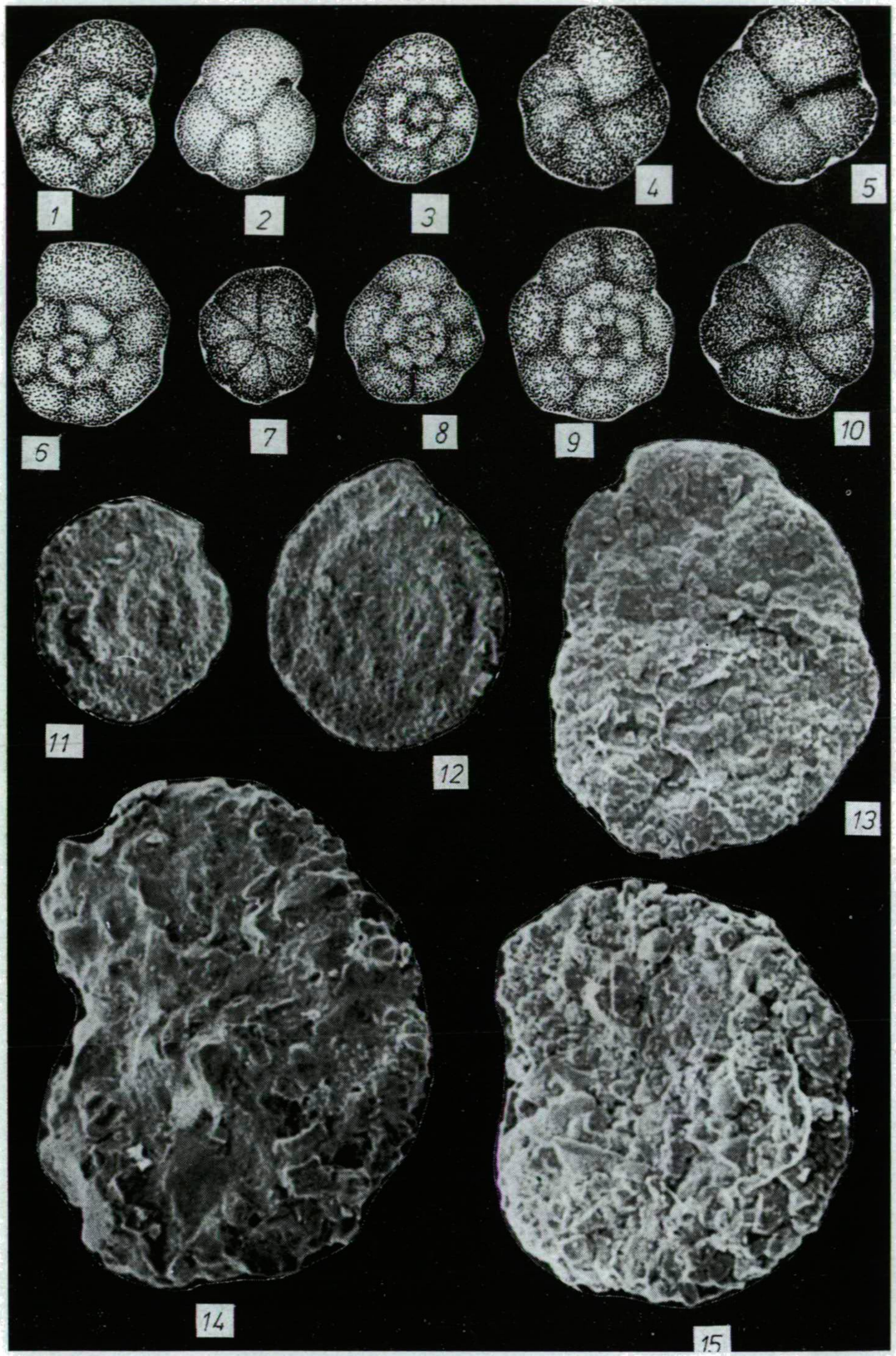


PLATE III

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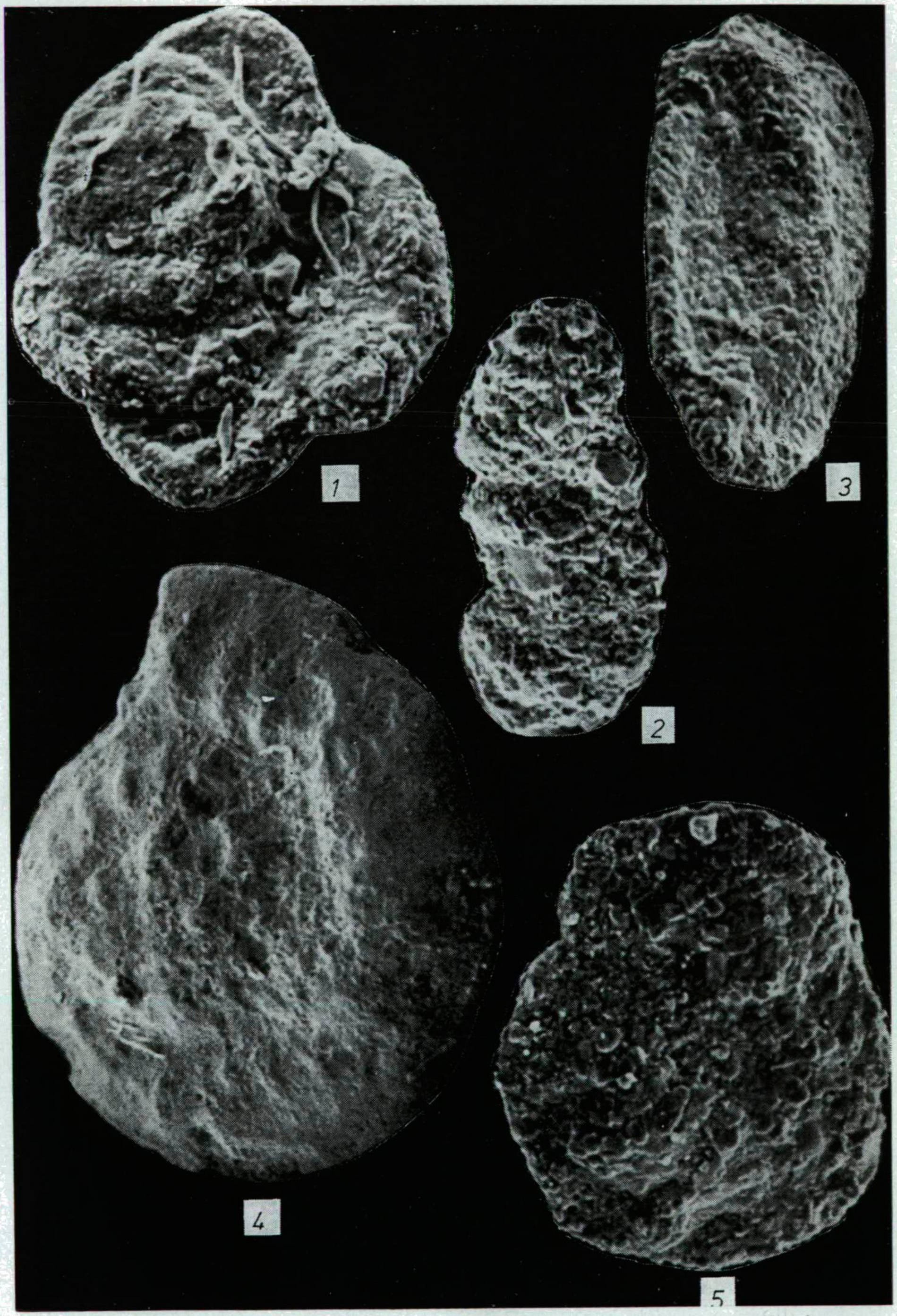
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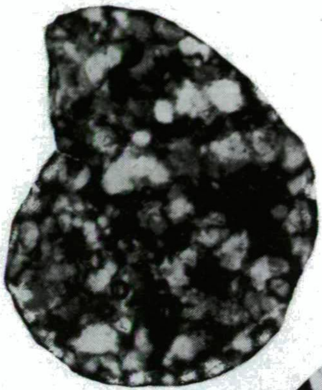

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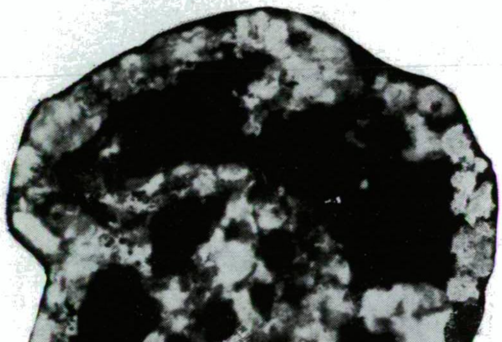

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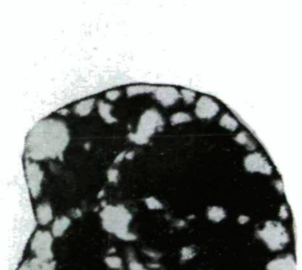

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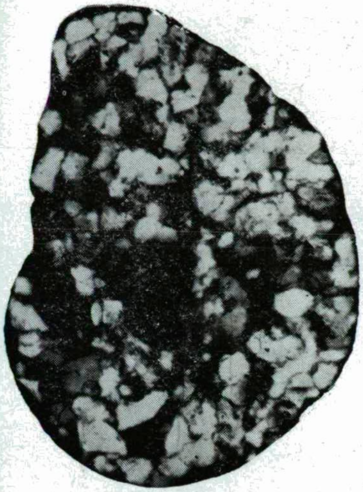
PLATE VII



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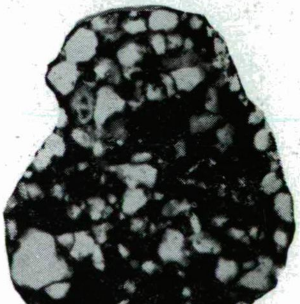

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Acta Mineralogica-Petrographica, Szeged, XXII/2, 339—351, 1976

SOME TRACE ELEMENT CONTENTS OF THE COMMON BASEMENT ROCKS OF THE SAFAGA REGION, EASTERN DESERT OF EGYPT

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ABSTRACT

Fourteen samples from the common igneous types forming the basement in the Safaga area were analysed by emission spectrography and neutron activation techniques and their contents n the following 22 trace elements were determined: B, Ba, Be, Co, Cr, Cs, Cu, Hf, La, Ni, Pb, Rb, Sc, Sm, Sr, Ta, Th, U, V, Y, Yb and Zr. The results obtained are discussed and compared with those of the corresponding world's averages.

All the Safaga basement rocks are apparently geochemically strongly impoverished in boron, ather impoverished in copper and lead but somewhat enriched in nickel, cobalt, and yttrium. The ranitic rocks are also rather impoverished in vanadium but rather richer in barium, strontium, hafnium and beryllium than the corresponding world's averages.

INTRODUCTION

Volcanics, subvolcanics and plutonic igneous rocks almost entirely form the asement rocks in the Safaga area. In a previous communication, GINDY *et al.* [1971] ad discussed the geochemical relations between the common basement rocks of the Safaga area. These relations were based on field observations and on chemical anayses for the major elements.

Away from the contact aureoles of younger intrusive rocks, the volcanics are lightly metamorphosed but other basement rocks are on the whole not metamorphosd or foliated. The granodiorite of Safaga is of batholitic dimensions, extending eyond the limits of the area studied and is variable in appearance, homogeneity and omposition.

In certain parts, it encloses several xenoliths, like metagabbros and hornblendeneisses. The batholith is truncated to the east by the Red Sea rift fault. The stratified olcanics occur in a deformed state in the sunken caldera of Gebel Nuqara, down nside the granodiorite and were thus protected from removal by erosion.

A "riebeckite-granite" intrusion occupied the fissures around the collapsed aldera and thus formed a ring-dyke but minor intrusions of the same granite were ent into all possible spaces and fractures of the country rocks. The adamellites also ccur as major intrusions into the granodiorite but the remaining "red-granite", uartz-porphyry and granit-porphyry intrusions occur as common late very minor rregular dyke intrusions dissecting all pre-existing rocks.

The different rock types of the analysed samples are given in Appendix 1 and heir locations are shown in *Fig. 1*, which also serves as a simplified geologic sketchap for the area studied.

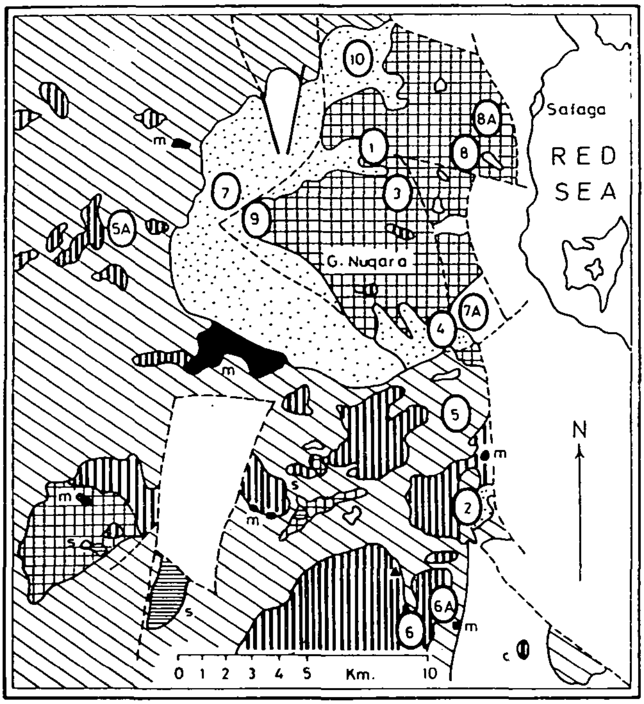


Fig. 1

PETROCHEMISTRY OF THE SAFAGA BASEMENT ROCKS

The technique used in the major element analysis was described earlier by GINDY *et al.* [1971]. The results of major element analyses for the 14 samples are given in Table 1, and the corresponding C. I. P. W. norms, NIGGLI values are given in Tables 2 and 3, respectively.

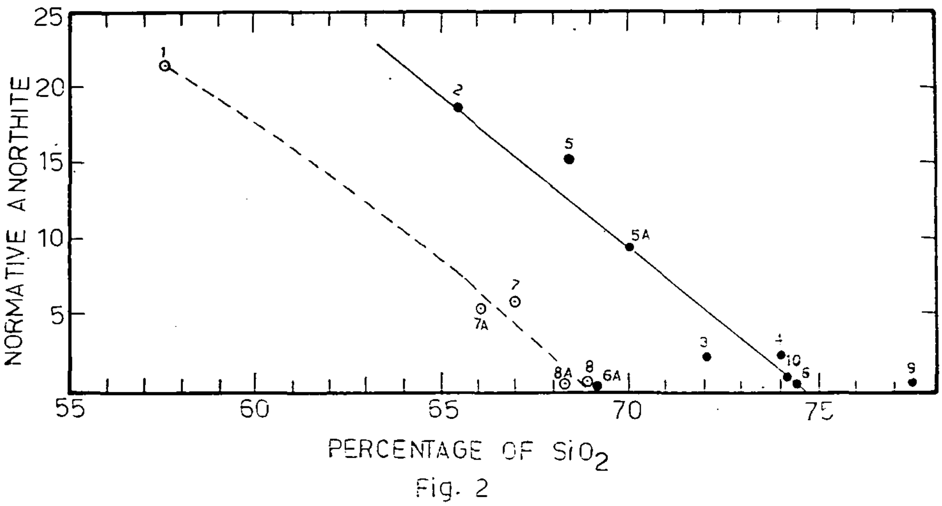


Fig. 2

TABLE 1

Complete chemical analyses (weight per cent) for the Safaga basement rocks

Oxides	1*	2*	3*	4*	5*	5—A	6*	6—A	7*	7—A	8*	8—A	9*	10*
SiO_2	57.53	65.43	72.05	73.85	68.69	70.10	74.37	68.80	67.08	66.06	69.23	68.25	77.51	74.17
Al_2O_3	18.16	15.68	11.83	12.69	14.39	15.59	12.06	15.23	15.41	14.74	13.67	14.21	9.83	13.08
Fe_2O_3	0.52	1.72	1.52	0.93	0.32	2.41	0.64	1.92	0.42	2.11	2.12	1.86	1.29	0.49
FeO	2.62	1.51	1.68	0.88	2.77	1.13	1.02	0.83	2.58	1.86	1.21	0.86	1.31	0.49
MnO	0.10	0.22	0.15	0.04	0.12	0.14	0.11	0.11	0.14	0.11	0.18	0.15	0.12	0.08
MgO	3.98	3.16	1.05	0.40	2.86	0.75	1.10	1.06	1.30	1.35	0.54	0.53	0.40	0.40
CaO	6.74	4.23	1.20	0.70	3.10	1.90	0.90	0.53	1.44	1.39	0.66	0.56	0.70	0.80
Na_2O	4.20	4.69	4.32	3.78	3.38	6.10	4.09	5.81	4.18	3.51	4.02	5.55	2.68	4.18
K_2O	2.45	1.05	3.64	5.19	2.80	1.51	5.04	5.83	5.38	6.01	7.09	7.47	5.40	5.42
TiO_2	1.34	0.92	1.02	0.36	0.62	0.50	0.32	0.25	1.04	1.13	0.70	0.23	0.42	0.32
P_2O_5	0.08	0.06	0.07	0.18	0.06	0.08	0.21	0.15	0.10	0.17	0.21	0.30	0.08	0.11
H_2O^+	0.16	1.49	1.49	1.10	0.56	0.61	0.45	0.38	0.53	1.10	0.41	0.39	0.40	0.42
H_2O^-	0.06	0.05	0.05	0.02	0.04	0.05	0.05	0.01	0.05	0.07	0.09	0.08	0.04	0.01
Total	99.92	100.21	100.07	100.12	99.57	100.87	100.36	100.90	99.65	99.61	100.13	100.44	100.18	99.97

* Values quoted from GINDY *et al.* [1971].

TABLE 2

C. I. P. W. Norms of the Safaga basement rocks

Norm	1	2	3	4	5	5—A	6	6—A	7	7—A	8	8—A	9	10
Qz	4.57	21.72	29.61	30.30	25.14	23.90	29.22	11.29	16.38	17.47	18.66	14.00	40.74	27.59
Or	14.49	6.12	24.52	30.58	16.68	8.89	30.02	34.47	31.69	35.52	41.70	44.10	31.69	32.06
Ab	33.50	39.82	36.51	31.96	28.82	51.50	33.01	45.74	35.11	29.65	31.44	31.10	20.44	35.33
An	23.42	18.63	2.11	2.22	15.29	9.00	—	—	6.39	5.97	—	—	—	0.88
C	—	—	—	—	0.10	0.62	—	—	0.41	0.35	—	—	—	—
Ac	—	—	—	—	—	—	1.85	2.95	—	—	2:31	5.30	1.85	—
Di	7.56	1.94	2.95	0.45	—	—	2.32	3.94	—	—	1.33	0.68	2.32	2.12
Hy	8.68	7.13	2.21	1.06	11.30	1.87	1.29	—	6.20	4.70	1.16	2.18	1.29	0.22
Mt	0.75	2.55	2.20	1.39	0.46	2.18	0.93	1.29	0.70	3.00	1.86	—	0.93	0.71
Hm	—	—	—	—	—	0.25	—	—	—	—	—	—	—	—
Il	2.53	1.82	1.94	0.76	1.22	0.94	0.76	0.47	1.98	2.14	1.37	0.42	0.76	0.61
Ap	0.19	—	0.16	0.34	0.13	1.60	0.34	0.35	0.34	0.35	0.67	0.70	0.34	0.26
Na metasilicate	—	—	—	—	—	—	—	—	—	—	—	2.24	—	—

TABLE 3

NIGGLI *values for the Safaga basement rocks*

NIGGLI values	1	2	3	4	5	5—A	6	6—A	7	7—A	8	8—A	9	10
si	179.3	250.5	378.9	327.4	285.5	318.2	407.9	303.4	295.8	300.0	335.4	316.3	506.7	424.7
al	33.3	34.8	36.6	43.0	35.3	41.6	38.5	39.5	39.9	39.4	38.9	38.7	37.6	44.0
fm	26.7	28.3	22.4	12.2	29.8	18.0	16.8	16.8	20.4	23.8	17.3	14.0	18.0	8.2
c	22.4	17.2	6.6	4.5	13.8	9.2	5.3	2.5	6.9	6.8	5.3	2.8	5.2	4.8
alk	17.6	19.7	34.4	40.3	21.3	31.1	39.5	41.2	32.8	32.8	40.3	47.0	39.2	43.0
ti	3.2	2.7	4.1	1.7	2.0	1.7	1.3	0.82	3.4	3.8	2.5	0.77	32.0	1.4
p	0.18	0.09	0.31	0.34	0.10	0.13	0.65	0.27	0.26	0.29	0.57	0.58	0.39	0.34
k	0.35	0.14	0.36	0.47	0.35	0.13	0.45	0.39	0.46	0.53	0.53	0.47	0.36	0.46
mg	0.70	0.63	0.38	0.28	0.62	0.28	0.55	0.41	0.43	0.38	0.23	0.26	0.23	0.42

TABLE 4

Trace element contents of the Safaga basement rocks
(values in ppm)

ELEMENT	1	2	3	4	5	5—A	6	6—A	7	7—A	8	8—A	9	10
B	4	1	1	1	11	1	3	1	3	1	1	1	1	1
Ba	750	70	826	250	410	143	950	1255	1102	1460	780	500	57	37
Be	2	1	2	7	2	5	11	4	4	7	4	4	11	13
Co	26	8	22	10	12	6	11	10	4	15	11	9	13	3
Cr	63	3	21	15	3	2	9	17	2	2	1	1	8	6
Cs	2.4	1.4	2.7	2	2.4	2.6	2.3	1.4	1.6	1.1	1.4	1.8	2.6	2.1
Cu	20	12	6	5	16	8	7	2	12	15	9	13	3	11
Hf	5.1	4.2	5.9	4	4.5	6.3	5.2	18	12.3	13.4	17.6	19.2	6.1	5.7
La	N. D.	27	27	58	5	2	58	86	27	27	56	48	96	56
Ni	98	10	48	9	38	17	20	18	7	8	7	6	14	8
Pb	6	9	14	23	5	10	11	16	11	10	11	11	14	22
Rb	10	17	47	95	29	70	85	88	53	76	66	120	124	100
Sc	7.2	18.3	9.2	2.4	1.1	2.5	2.8	1.8	9	6.2	5.7	3.5	2	1.3
Sm	7.5	6.6	5.9	6.4	8.4	7.3	5.4	9.8	11.1	12.2	12.6	10.2	8	3
Sr	520	290	423	273	410	330	285	430	305	320	240	225	130.2	40
Ta	0.3	0.4	0.9	1.9	0.6	0.8	1.8	2.4	2.6	2.7	2.9	2.8	1.9	1.4
Th	0.6	0.8	5	11	6.9	6	12.1	3.8	4	9.1	6.8	7.5	10	12.5
U	0.2	0.4	1.7	4.4	3	2.8	3.5	1.2	1.6	2.7	3.1	3.5	4.2	5.3
V	115	15	63	32	129	31	5	19	6	15	12	2	11	2
Y	N. D.	55	15	24	24	22	24	22	12	24	31	32	73	12
Yb	2.7	3.3	3	3.1	2.6	2.6	2.4	2.6	2.2	3	3	2.6	3.4	2.2
Zr	480	640	440	670	390	420	395	395	450	470	560	700	190	68

N. D. = not detected.

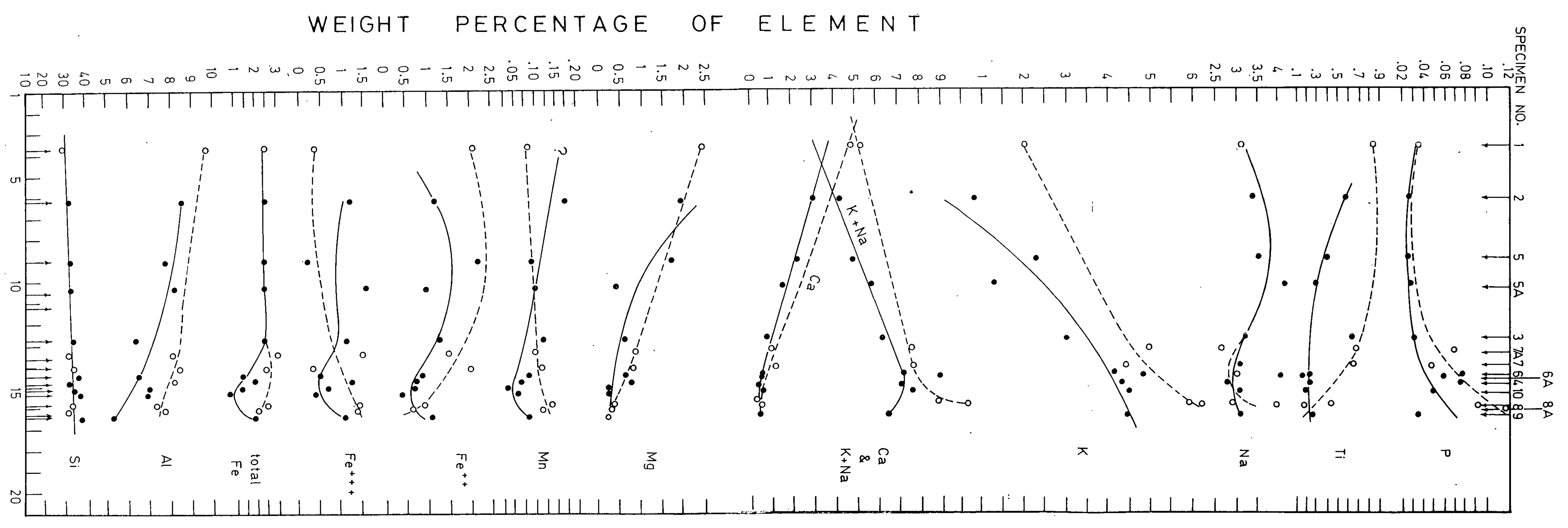

WEIGHT PERCENTAGE OF ELEMENT
SPECIMEN NO.
DIFFERENTIATION INDEX (1/3 Si+K)-(Ca+Mg)
Si
Al
total Fe
Fe+++
Fe++
Mn
Mg
Ca & K+Na
K+Na
Ca
K
Na
Ti
P

Fig. 3

In the different diagrams of *Figs. 2* to *6*, plotting of the newly analysed "riebeckite-granite" and "red-granit" samples nos. 7A and 8A, each fall very near to those of the corresponding samples analysed earlier (nos. 7 and 8).

The new granodiorite sample (no. 5A) is, however, much more sodic, slightly higher in total iron but poorer in potash, magnesia and lime than the first granodiorite sample no. 5. On the other hand, plots of the hybrid adamellite sample no. 6A interestingly often follows the slightly alkaline suite *(Figs. 2, 4, 5* and *6)* suggesting some drawing out of alkalies, especially soda from the enclosed darker granodioritic xenoliths and their addition to the enclosing adamellite.

Field evidence for the transitions occurring between the granodiorite and adamellite are present though they are very few. Except for the adamellite, the bulk size of the rest of the normal calcalkaline intrusives is very small. The adamellite in addition might have also been generated by small weaker renewed activation and remelting of the deeper part of the granodiorite batholith itself whether it had already solidified or was solidifying.

Alkalic (potassic) fluxing activities by volatiles and hyperfusible constituents during magmatic intrusion of the normal adamellite magma under sub-volcanic,

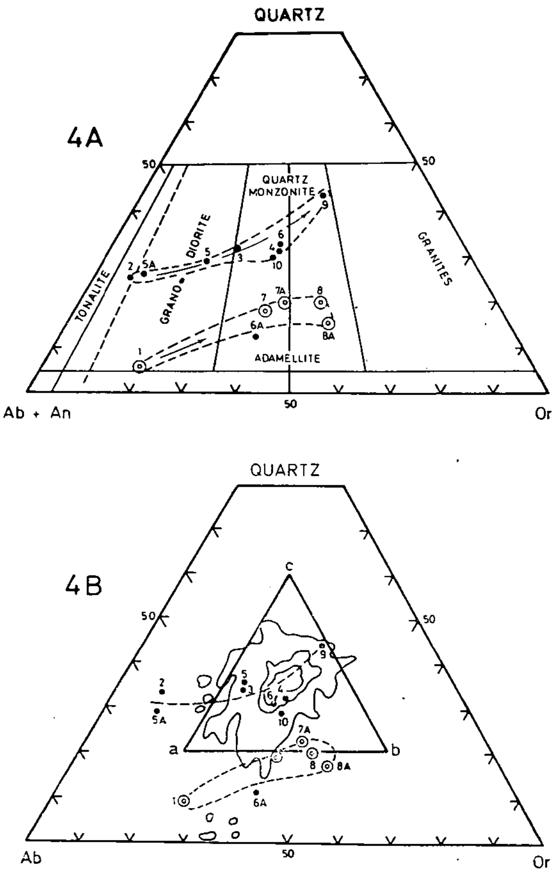


Fig. 4

superheated condition are considered to account for the slight alkalinity shown by the "riebeckite-granite" of the ring-intrusion. The later "red granite" intrusions might similarly have evolved through strong potassic hyperfusible and volatile activities on late minor granitic pockets of residual magmas.

From the variation diagrams of *Fig. 3*, it can be noticed that almost no significant changes occur in the curves for sodium and total iron except perhaps at differentiation indices above 14. Irregularities in the ferrous and ferric curves must have in part, been affected by the original state of oxidation of iron and the extent of its

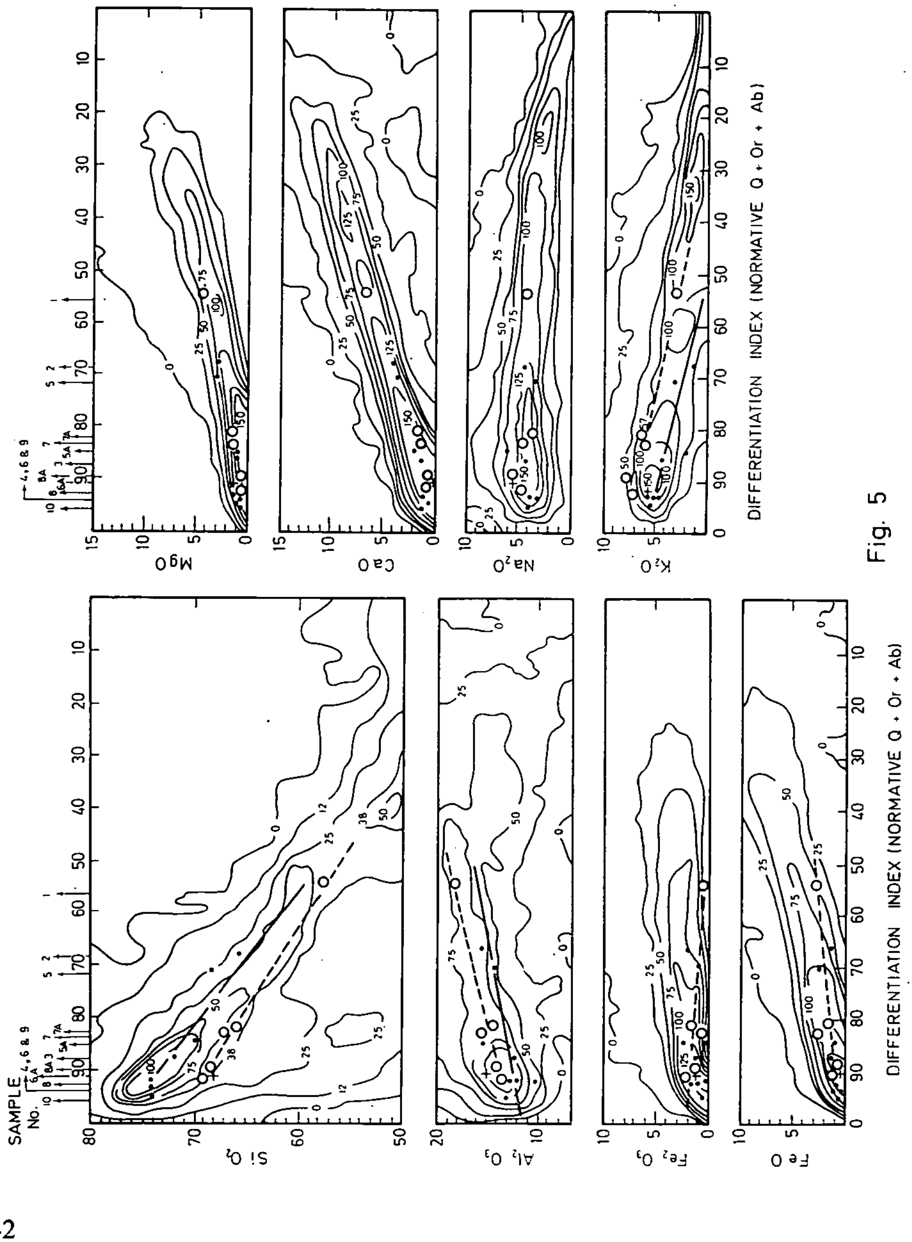


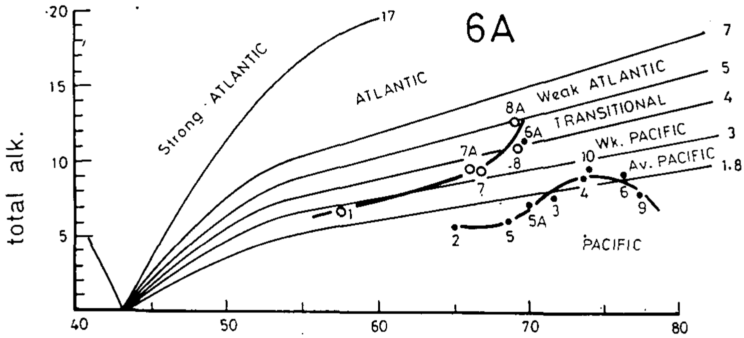
Fig. 5

oxidation during volcanic extrusion and/or subsequent metamorphism or hydrothermal acitivities subsequent to intrusion.

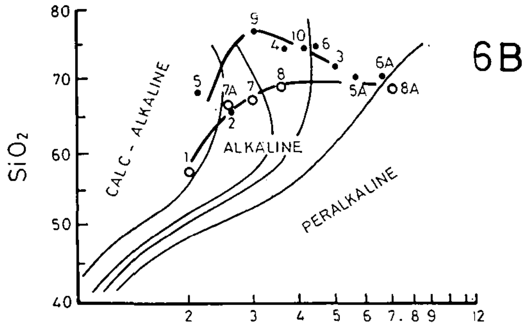
Conventially, phosphorous decreases with increasing acidity except in certain pegmatitic residua, but in the curves for both suites of Safaga, phosphorous increases with increasing acidity and is slightly higher for alkaline than calc-alkaline suite. This suggests some concentration of phosphorous in the "residual magma" at Safaga, but late gaseous transfers could also be invoked for this increase.

It is seen from *Fig. 4B*, that apart from the dacite sample no. 2, all calc-alkaline members fall within the contour of maximum frequency of 1269 igneous rocks in Washington's tables containing 80%. or more of normative (Ab+Or+Q). The five alkaline samples of trachandesite (no. 1), "riebeckite-granite" (no. 7, 7A) and "red granite" (no. 8, 8A) all fall outside these contours although the normative (Ab+Or+ +Q) of the last four alkaline samples exceed 80.

Direct treatment and comparison of data of the analysed "volcanics" (samples nos. 1, 2, 3 and 4) with those of the "plutonites" may be debatable because of the possible interfering effects of volcanicity on varying the actual igneous primary



RITTMANN'S σ DIAGRAM



J.B. WRIGHT'S ALKALINITY RATIO

Fig. 6

composition of the lava, e.g. by gaseous transfer and other effects of vapours and sublimates and oxidising conditions. This collective treatment and correlation of the "volcanics" and "non volcanics" of Safaga may be here justified by the belief that a very close genetic relationship existed between these volcanics and some of the granitoids.

GEOCHEMISTRY

Trace element analysis:

Two methods were applied to determine 22 trace elements for all the 14 rock samples.

1 — Spectrochemical method for determining B, Ba, Be, Co, Cr, Cu, La, Ni, Pb, Sr, V, Y, Yb and Zr.

2 — Neutron activation technique to determine Cs, Hf, Rb, Sc, Sm, Ta, Th and U.

For the first method, the spectrograph used is a Q—24 Carl Zeiss medium quartz spectrograph supplied with an intermittent D. C. source. The generating power is a Carl Zeiss ABR3 with a maximum voltage of 28 kV at 220 V. Operating conditions for arching, technique of work as described elsewhere, ANWAR *et al.* [1971].

For the second method ,the neutron activation scheme used was based on different irradiation (A. C.) carried out at a thermal neutron flux of 1.5×10^{13} n/cm^2 sec. The detector used for this study was a coaxial Ge(Li) detector with a resolution of 2.5 keV (FWHM), detail of the method, see ANDERS, [1969], and BRUNFELT *et al.* [1969, 1974].

The trace element data are presented in Table 4. It is clear from the analysis, that sample no. 10 of the latest and most acid one (with high D. I.) in Safaga, possesses the lowest content of Ba, Sr, V, Co, Y, Yb, La and Sm. It is also impoverished in Ni and Cr. On the other hand, sample no. 1 of the trachyandesite is the most basic and it possesses the highest content of Sr, Cr, Ni and Co and is also enriched in V, Cu and Cs.

Trace element contents of the adamellite, "riebeckite-granite" and "red granite" are roughly closer to each other but are quite different from those of the Safaga granodiorites. The "red granite" sample no. 8A shows higher values of Hf, Ta, Rb, Th and U, and lower values of Ba, Sr, Co and Ni than the "riebeckite-granite" sample no. 7A. The adamellite sample no. 6A has higher values of Ba, Cr, Hf and Ta and lower data for Cu, Th and U than the granodiorite sample no. 5A.

In all the diagrams, plots of the normal calc-alkaline suite are represented by solid black circles, plots of the alkali-calcic suite (samples nos. 1, 7, 7A, 8 and 8A) are shown by centered open circles, while plots of the hybrid adamellite sample no. 6A are shown by crosses.

The behaviour of the 22 determined trace elements may conveniently be studied under the following six groups:

1 — *Ba, Sr, Pb, Rb and Cs*

Both Ba and Sr decrease with strong differentiation. Furthermore, two trends may be observed for Ba and Sr in the calc-alkaline and alkali-calcic suites. In *Figs. 7A* and *7B*, both elements are relatively higher in the alkali-calcic suite than in the normal suite.

Figs. 7C and *7D* show an increase of Pb with increase of D. I. and with high K contents, respectively. The calc-alkaline suite is relatively richer in Pb than the alkali-calcic suite as Pb is readily captured and admitted by K.

There is functional antipathetic relation between Ba and Rb, *Fig. 8A*, where two possible trends could be suggested. The "riebeckite-granite", "red granite" and the

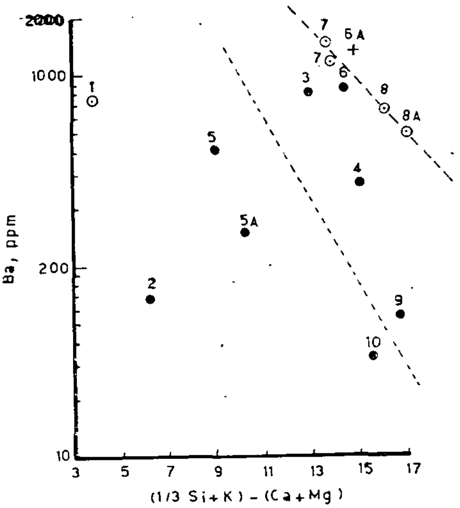


Fig. 7A

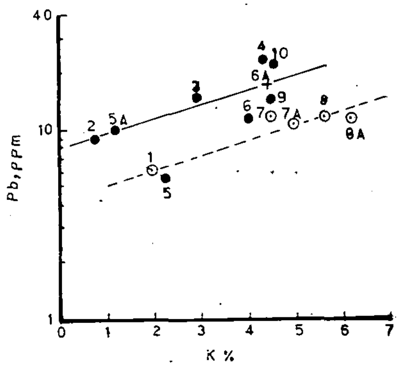


Fig. 7C

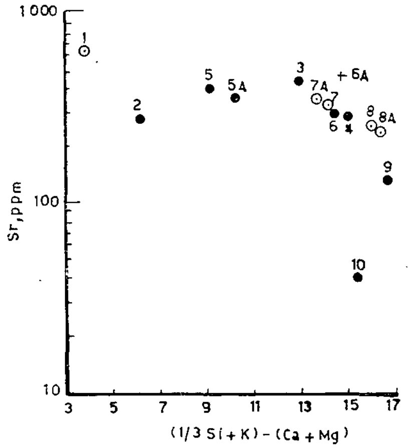


Fig. 7B

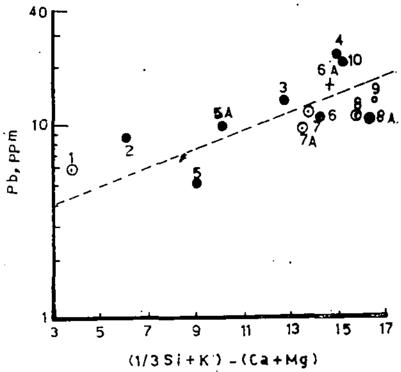


Fig. 7D

adamellite samples show general enrichment in Ba beside a depletion in Rb. The trachyandesite sample no. 1 shows strong depletion in Rb and an enrichment of Ba, in contrast to the quartz-porphyry sample no. 9 and the late rhyolite dyke sample no. 10 which have higher Rb values than Ba. This probably suggest that the tonalite might have evolved later by partial remelting of the earlier granodiorite formed by anatexis or by direct magmatic differentiation from the newly formed granodioritic magma.

2 — *V, Cr, Co and Ni*

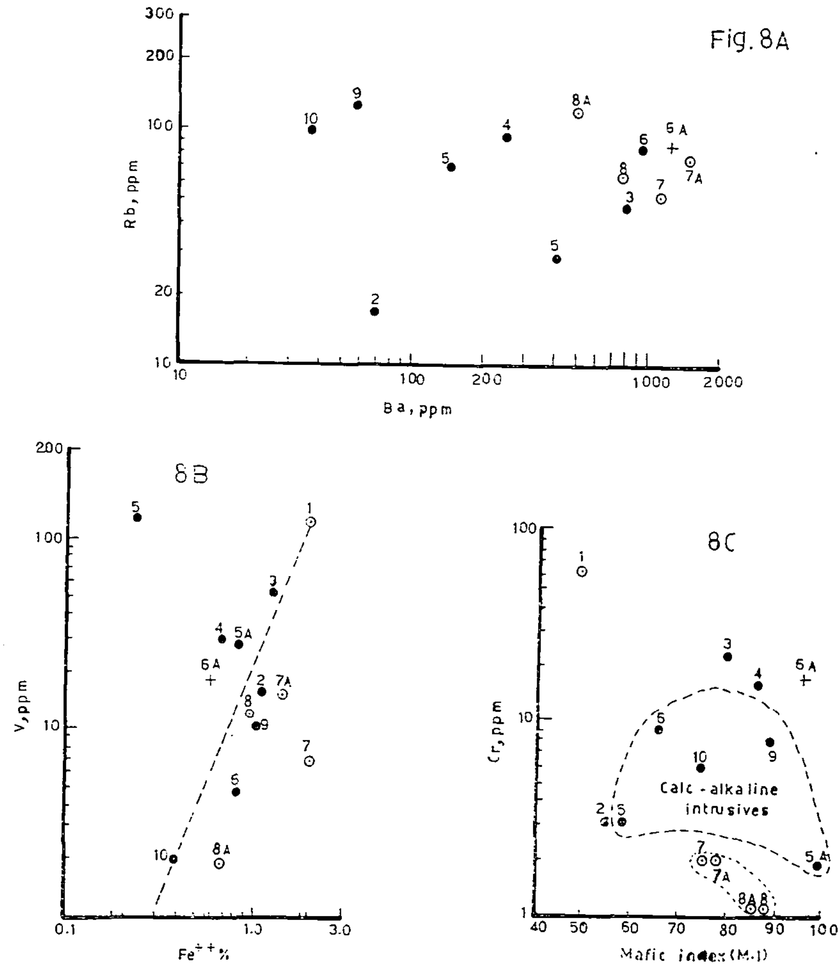
These elements are known to follow Mg and Fe in their geochemical behaviour. All decrease with increase of D. I. *Fig. 8B* indicates an increase of V with Fe^{++}, the granodiorite sample no. 5 possesses a high value of V and occupies a separate position. *Fig. 8D* shows two fields for the alkali-calcic suite of Safaga ("riebeckite and red granites") and the calc-alkaline intrusions.

3 — *B, Be and Cu*

Boron contents of the Safaga basement rocks are notably very low compared with those of the corresponding world's average. Actually not a single crystal of tourmaline was observed in all the studied collection of thin sections from the Safaga basement rocks.

Be increases with the increase of differentiation index of the Safaga basement rocks. This agrees eith BEUS's data [1956], for igneous rocks in general as quoted by TAYLOR [1965].

Coherence of Be concentration to silicon content of rocks has been pointed out by SHAWE and BERNOLD [1964]. It will be noticed from *Fig. 9A* that sample nos. 9, 10 and 6 possess high silica as well as high Be contents. The alkali-calcic suite of Safaga seems to occupy a distinct field in this figure.



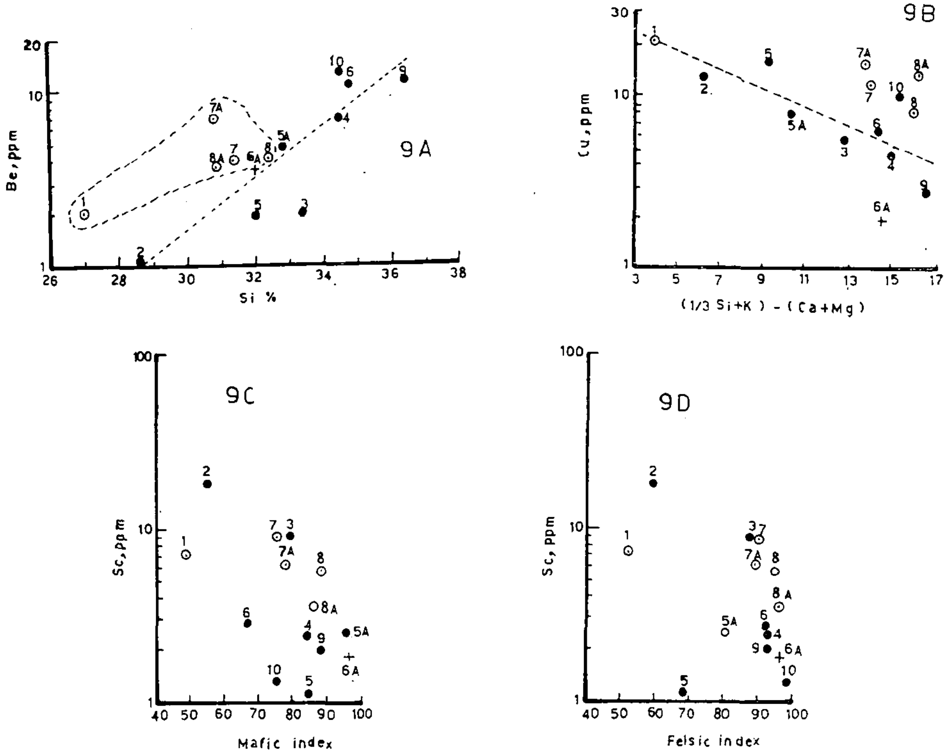


Fig. 9

As can be seen from *Fig. 9B*, Cu decreases with increase of differentiation index in Safaga. In general, Cu is relatively high in the "riebeckite and red granites", meta-dacite and rhyolite dyke of Safaga although the highest contents are those of the trachyandesite and one of the granodiorite samples.

4 — *Y, Yb, La, Sm and Sc*

Yttrium and the lanthanides (including Yb) can substitute for Ca^{++} of some accessory minerals in granite like apatite, titanite, epidote and fluorite [RANKAMA and SAHAMA, 1952; GOLDSCHMIDT, 1954 and MASON, 1964]. Y, Yb and La elements do not show a clear relation with the differentiation index in the Safaga basement rocks.

In general, the alkali-calcic suite of Safaga tends to have higher Sm values than the calc-alkalic suite. Sc decreases with increase of the differentiation index in Safaga rocks. Sc contents appear to be higher in members of the alkaline-calcic suite than the corresponding members of the calc-alkaline suite. The complex behaviour of Sc may be shown by its decrease with increase of both mafic and felsic indices, *Figs. 9C* and *9D*.

5 — *Zr, Hf and Ta*

Zirconium and hafnium form a pronouncedly coherent pair of elements [RANKAMA and SAHAMA, 1952]. The abundance of Zr in igneous rocks has been considered by CHAO and FLEISCHER [1960]. This paper shows very clearly the increase of Zr with fractionation.

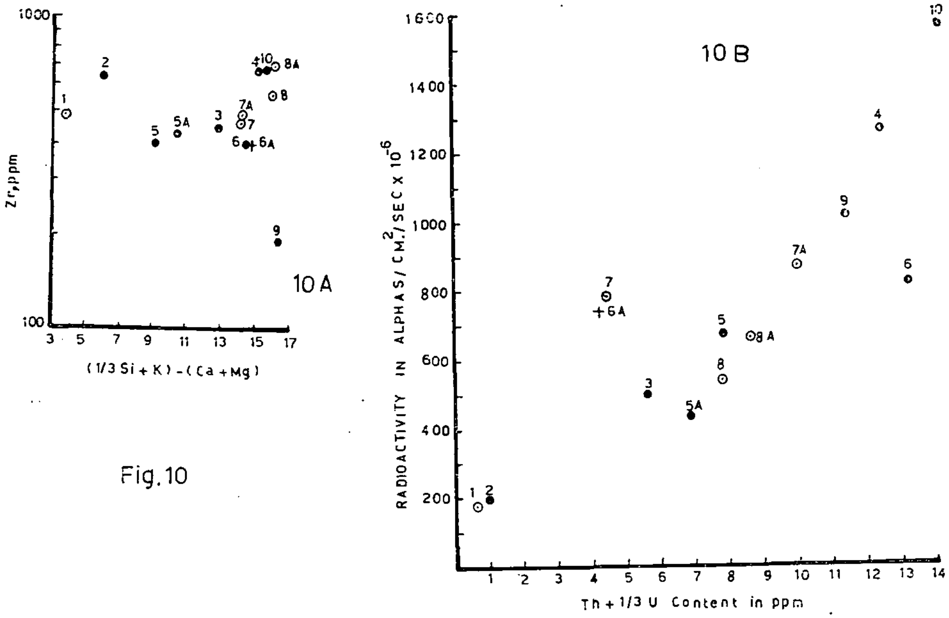


Fig.10

For the Safaga basement rocks, Zr appears to increase with increase of the differentiation index, (*Fig. 10A*) which is the normal trend in igneous rocks [TAYLOR, 1965]. No clear distinction between the two Safaga suites could be made on the basis of their Zr contents.

The alkali-calc suite of Safaga basement rocks show higher Hf values (av. 156. ppm), and lower Zr/Hf ratio (av. 35) than the calc-alkali suite which has an average value of 5.2 ppm Hf and 112.7 for Zr/Hf ratio.

Ta may substitute for Ti^{4+} and Zr^{4+}. In the Safaga basement rocks, the alkali-calc suite shows an average value of 2.8 ppm Ta, while the calc-alkaline suite has an average of 1 ppm Ta.

6 — *U and Th*

Quadrivalent uranium and thorium are geochemically coherent due to similarities in oxidation state and ionic radius. The relation between U and Th from one hand and differentiation from the other is the subject of considerable research. However, there is general agreement that both U and Th increase with differentiation, but the controversial Th/U ratio can either increase or remain constant with differentiation [RAGLAND *et al.*, 1967]. In the Safaga basement rocks, the ratio of Th/U is more or less constant, it varies from 2 to 3.5.

Fig. 10B indicates that the summation of $Th+\frac{1}{3}U$ in the Safaga basement rocks increases with alpha radioactivity and the most radioactive rocks are the acid ones (ignimbrite, rhyolite dyke and quartz-porphyry of samples nos. 4, 10 and 9.

WHITFIELD *et al.* [1959], found that there is greater petrogenetic control of thorium than of uranium content, and this may be explained on the basis of oxidation and repeated loss of uranium from magmas during the later stages of their differentiation.

SUMMARY AND CONCLUSIONS

From the preceding study on the behaviour and distribution of the trace elements of Safaga basement rocks, the following conclusions may be summed up.
1 — Cu, Sc, Sr, Cr, Co, Ni and Ba contents of the basement rocks of Safaga decrease with increase of their differentiation index, while Pb, Be, Rb, U, Th and Zr increase.
2 — The trachyandesite sample no. 1 is enriched in Ca and Mg and also in V, Cr, Co and Ni contents. This supports the suggestion previously expressed in GINDY *et al.* [1971], that a weak alkalinity of this rock is caused by original mixing of a basaltic magma and acidic anatectic magma or by mixing of their differentiates. In the "riebeckite- and red granites" the weak alkalinity is believed to be caused by potassic fluxing under subvolcanic superheated conditions. It is worth to mention that the "riebeckite and red granites" are enriched in Ba, Rb, Zr, Hf and Ta.
3 — The hybrid character of the granitoid, sample no. 6A, at the transitional contact between a xenolith granodiorite and adamellite in Safaga is reflected in the major and trace element contents of that rock.

Compositional plotting of the different elements in that rock often oscillate between those of the two petrogenetic suites of Safaga whenever a distinction between the two suites becomes apparent in the diagram.
4 — Geochemically the Safaga basement rocks are distinctly impoverished in boron. If the data for the granodiorite, trachyandesite and dacite samples of Safaga are averaged, their average contents in Ba, Sr, V, Yb, Sc, Rb, Zr, and Be generally agree with the corresponding values for the world's average granodiorite.

The large decrease in Cr contents of the two Safaga granodiorites could be due to the suggested origin by differential melting of the Safaga granodiorite from pre-existing rocks at deeper levels of the crust. However, the nine Safaga samples are impoverished in V, and Cr and enriched in Ba, Rb, Sr, Y, La, Sm, Th, Hf and Zr.

ACKNOWLEDGMENTS

The authors acknowledge the cooperation of MR. A. O. BRUNFELT at the Mineralogisk-Geologisk Museum, at the University of Oslo, Norway, for his advices in neutron activation analysis.

APPENDIX 1

Rock types and locations of the analysed samples

1— Trachyandesite (field-number of 653) from the volcanic succession of Gebel Nuqara.
2— Dacite (field-number of 300) least affected parts of a large mechanically stopped block inside the adamellite intrusion, Wadi Safaga area.
3— Rhyolite (field-number of 410) from the pile of volcanic flows of Gebel Nuqara.
4— Rhyolitic ignimbrite (field-number of 254) from Gebel Nuqara volcanics, northern bank of Wadi Nuqara.
5— Granodiorite (field-number of 565) from Wadi Um Ifein.
6— Adamellite (field-number of 317) Um Huetat area, from a big homogeneous intrusion.
7— "Riebeckite-granite" (field-number of 90) Wadi Um Taghir, on the present Quena-Safaga motor-road.

8— "Red-granite" (field-number of 385) intruded into the volcanic succession north of the triangulation point of Gebel Nuqara.

9— Quartz-porphyry dyke (field-number of 568) intruded into the volcanics of the western parts of Gebel Nuqara.

10— Late rhyolite dyke (field-number of 191) cutting into riebeckite-granite, and also truncating porphyry intrusions in the riebeckite-granite.

5A— Granodiorite (field-number of 124) from the medium grained dark granodiorite in Wadi Um Taghir.

6A— Adamellite (field-number of 310) from Wadi Um Huetat, and the sample was selected from the adamellitic part in between the granodioritic inclusions.

7A— "Riebeckite-granite" (field-number of 252) from small discrete intrusion in the ignimbrite flows at the mouth of Wadi Nuqara.

8A— "Red granite" (field-number of 88) from small discrete red intrusion in the dark meta-volcanics facing Safaga town.

APPENDIX 2

Comparison between the average contents of some trace elements in the Safaga basement rocks with those of the corresponding world's averages. (values in ppm)

Element	SF. 1	T. W. 1	SF. 2	T. W. 2	SF. 3	T. W. 3
B	4	5	4.3	9	1.5	10
Ba	750	330	343.3	420	710	480
Be	2	1	2.5	2	7.2	3
Co	26	48	13	7	9.6	1
Cr	63	170	17.8	22	6.8	4.1
Cs	2.4	1.1	2.2	2	1.8	4
Cu	20	87	14	30	8.6	10
Hf	5.1	2	5	2.3	11.3	3.9
La	N. D.	10	11.3	45	56.9	55
Ni	98	130	40.8	15	10.8	4.5
Pb	6	6	7.5	15	14.3	19
Rb	10	30	31.5	110	89.7	170
Sc	7.2	30	7.3	14	3.8	7
Sm	7.5	5.3	7.5	8.8	8.8	10
Sr	520	465	387.5	440	249.8	110
Ta	0.32	1.1	0.5	3.6	2.3	4.2
Th	0.6	4	3.6	8.5	8.5	17
U	0.2	1	1.6	3.0	3.3	3
V	115	250	72.5	88	11.6	44
Y	N. D.	21	33.7	35	28.2	40
Yb	2.7	2.1	2.8	3.5	2.7	4
Zr	480	140	482.5	140	501.1	175

SF. 1 — Trace element contents of the trachyandesite sample no. 1.

T. W. 1.: Average contents in basaltic rocks of the World's (after TUREKIAN and WEDEPOHL, 1961).

SF. 2.: Average contents of the Safaga samples nos. 1, 2, 5 and 5-A.

T. W. 2.: Average contents for the World's high-calcium granitic rocks (granodiorites), after TUREKIAN and WEDEPOHL, 1961.

SF. 3.: Average contents of the nine Safaga samples nos. 4, 6, 6-A, 7,7-A, 8, 8-A, 9 and 10.

T. W. 3.: Average contents for the World's low-calcium granitic rocks (granites), after TUREKIAN and WEDEPOHL, 1961.

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PRODUCTION OF REFRACTORY MATERIAL OF BADDELEYITE AND CORUNDUM

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ABSTRACT

This work represents a study of the production of refractory material of baddeleyite and corundum from Rosetta zircon. This method is based on sintering of zircon with aluminum fluoride in presence of graphite. The desilication of zircon with the formation of baddeleyite and corundum was found to take place optimally at 850 °C at 1 hour using zircon, aluminium fluoride and graphite mixes of ratio 1:0.8:0.1. Also, the behaviour of zircon was studied under different sintering conditions.

INTRODUCTION

For production of high quality refractory material of baddeleyite and corundum mixture (zirconium and aluminium oxides), zircon is converted into the oxide and then mixed with corundum. The chemical processing of zircon for production of zirconium oxide achieved by different methods (2, 3, 5, 8, 9, 17). These include sintering of zircon with alkali or soda and hydrometallurgical digestion with alkali solutions. Sintering of zircon with aluminum fluoride is a good variant for direct production of refractory material of zirconium and aluminum oxides.

The fluorinating action of fluorine, fluorides and hydrogen fluoride are well known and the solid fluorinating agents are very important, since they have many advantages (6, 7, 10—12). The desilication of Rosetta zircon with aluminum fluoride in presence of graphite was previously investigated by thermal analysis (1). The DTA curves show a sharp exothermic peak at 580 °C, representing the burning of graphite with little formation of aluminum silicon fluoride. The endothermic peak at 820 °C represents the intensive desilication of zircon with aluminum fluoride and the volatilization of silicon tetrafluoride. The desilication results in the formation of baddeleyite and corundum which are suitable as high quality refractory material (1, 7—9, 12, 15, 17).

This work represents a study of the behaviour of Rosetta zircon during sintering under different conditions and the influence of different factors acting upon sintering. The optimum conditions of production of this refractory material of baddeleyite and corundum were determined.

EXPERIMENTAL WORK

This research was carried out with zircon concentrate separated from the Egyptian black sands. Its chemical and mineralogical composition are given in tables (1) and (2) respectively. It is seen that the concentrate contains some mineral impurities with which zircon is genetically connected as rutile, monazite, garnet and others. They are present as fine grains and in small quantities. Non of these mineral impurities was detected by X-ray analysis. Hence, no individual mineral may be present as a major constituent and which is consistent with the mineralogical analysis data.

TABLE 1

Chemical composition of zircon concentrate

Chemical component	Content (%)
ZrO_2	62.73
SiO_2	32.65
Fe_2O_3	1.64
TiO_2	1.23
ThO_2	0.05
RE_2O_3	0.31
Al_2O_3	1.12
P_2O_5	0.22

TABLE 2

Mineralogical composition of zircon concentrate

Mineral	Content (%)
Economic Minerals:	
Zircon	94.81
Rutile	1.12
Ilmenite	0.47
Monazite	0.81
Magnetite	0.40
Gangue Minerals:	
Epidote	0.96
Glauconite	0.25
Garnet	1.10
Feldspars	0.15
Amphiboles	0.10

Mixes of zircon concentrate, aluminum fluoride and graphite in particular amounts were ground in an automated agate mortar and sieving till all the powder pass through 0.07 mm sieve and pestle for one hour to achieve homogenity. Sintering experiments were carried out in platinum crucibles heated in an electrical tube furnace under removal of volatilized silicon tetrafluoride. The temperature is regulated automatically with accuracy ± 10 °C. The duration of every run was considered from the moment of reaching the particular temperature.

X-Ray Procedure

The end products of zircon sintering at the optimum conditions were examined by X-ray powder diffraction analysis using a Siemens Crystalloflex diffractometer. The finely ground sintering product was mixed with sodium chloride as a standard. Its peaks occuring at $2\Theta = 31.38°$ and $45.44°$ were used for corrections. Nickel filtered copper radiation was used. Exposure was one hour. Scanning speed was $1°$ 2Θ per minute at one cm per min. chart speed. Intensities were collected to maximum $2\Theta=65°$. The sensitivity of the experiment was 4×10^4 impl./min and the statistical error is 1.5%.

Efficiency of desilication and sintering of zircon

The efficiency of sintering and desilication of zircon was determined by the amount of silica removed with respect to that in the initial zircon concentrate. The end product of sintering was chemically analysed for its silica content by Riley method and by activation analysis.

Determination of thermodynamic constants

Before studying the conditions of desilication of zircon with aluminum fluoride, an attempt was carried out for calculation of its thermodynamic constants. The thermodynamic data given in Table 3 were used in calculation.

TABLE 3

Thermodynamic data used

Thermodynamic function	Value, Kcal/mol	Reference
$\Delta F°$ Corundum (c)	−378.2	(16, 18)
$\Delta F°$ ZrO_2 (c)	—244.4	(13, 16)
$\Delta F°$ AlF_3 (c)	—294.0	(14)
$\Delta F°$ SiO_2 (c)	—192.4	(13, 14)
$\Delta F°$ SiF_4 (g)	—360.0	(13)

The free energy of zircon can be calculated from the following reaction:

$$ZrSiO_4 \rightarrow ZrO_2+SiO_2$$

At equilibrium conditions,

$$\Delta F°_{reaction}=\Delta F°_{ZrO_2}+\Delta F°_{SiO_2}-\Delta F°_{ZrSiO_4}=0$$

$$=-244.4-192.4-\Delta F°_{ZrSiO_4}=0$$

$$\Delta F°_{ZrSiO_4}=-436.8 \text{ Kcal/mol.}$$

The reaction of sintering of zircon with aluminum fluoride may be represented as:

$$3\,ZrSiO_4+4\,AlF_3 \rightarrow 3\,ZrO_2+2\,Al_2O_3+3\,SiF_4$$

The standard free energy of the reaction:

$$\Delta F°_{reaction}=3\Delta F°_{ZrO_2}+2\Delta F°_{Al_2O_3}-3\Delta F°_{SiF_4}+3\Delta F°_{ZrSiO_4}-4\Delta F°_{AlF_3}$$

$$=-733.2-756.4-1080+1310.4+1176$$

$$=-2569.6+2486.4=-83.2 \text{ Kcal/mol.}$$

The equilibrium constant of the reaction of desilication of zircon may be calculated from equation at 25 °C:

$$\log K = \frac{-\Delta F^\circ}{4.575 \times 298} = -0.000733\Delta F^\circ$$

$$= 0.000733 \times 832000 = 60.986$$

$$K = 9.68 \times 10^{60}$$

The equilibrium constant is very large and the reaction of desilication of zircon with aluminum fluoride may be practically considered as irreversible.

RESULTS AND DISCUSSION

The essential factors, which have a considerable influence on sintering of Rosetta zircon with aluminum fluoride in presence of graphite can be grouped as:
1 — Influence of graphite and its amount.
2 — Influence of the amount of aluminum fluoride.
3 — Influence of temperature and time.

1 — Influence of graphite and its amount

For studying the influence of graphite and its amount on desilication of zircon, a series of experiments were carried out using zircon mixes with aluminum fluoride, containing different amounts of graphite at ratio of zircon: graphite = 1:0.05, 0.1, 0.15 and 0.2, at 850 °C during 1 hour.

From the obtained results *(Fig. 1)*, it is shown that the desilication efficiency of zircon sharply increases with the amount of graphite, corresponding to ratio zircon: graphite = 1:0.1. Above this value, the efficiency decreases. Also, the desilication efficiency of zircon increases with the amount of aluminum fluoride corresponding to ratio of zircon: aluminium fluoride = 1:0.8 to 1:0.9.

It is observed that the addition of graphite in a suitable amount (at ratio of zircon: graphite = 1:0.1) in zircon mixes accelerates its desilication.

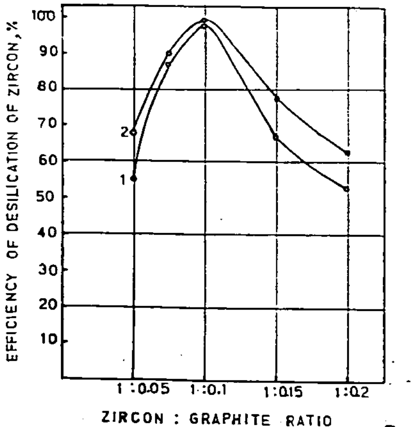

Fig. 1

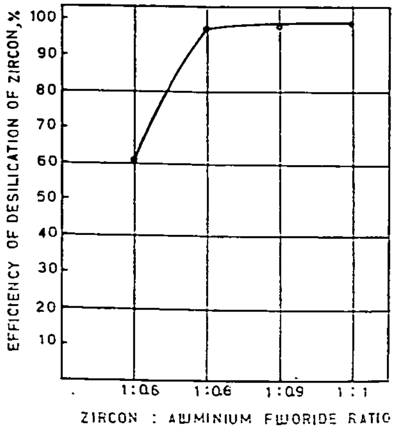

Fig. 2

2 — Influence of the amount of aluminum fluoride

For determination of the optimum amount of aluminum fluoride, at which complete desilication of zircon takes place, sintering was carried out using different amounts of aluminum fluoride corresponding to ratios of zircon : aluminum fluoride = 1:0.6, 0.8, 0.9 and 1:1, at 850 °C during 1 hour.

As shown in *Fig. 2*, the desilication of zircon sharply increases with the amount of aluminum fluoride at ratio of zircon: aluminum fluoride = 1:0.6 to 1:0.8. Beyond this value, any increase in the amount of aluminum fluoride has little effect on desilication of zircon.

From the results obtained, the optimum amount of aluminum fluoride can be considered as amount corresponding to ratio of zircon: aluminum fluoride = 1:0.8.

3 — Influence of temperature and time

To study the influence of both temperature and time on desilication of zircon, sintering experiments were carried out at fixed amount of aluminum fluoride and graphite, (corresponding to ratio of zircon: aluminum fluoride: graphite = 1:0.8:0.1) at temperature 600°—1100 °C during 1 hour and at 850° and 900 °C for duration 20—90 min.

From the obtained results *(Fig. 3* and *4)*, the following conclusions may be drawn:

1. In general, as the temperature increases, the desilication efficiency of zircon increases with time.
2. The sharp increase of desilication efficiency of zircon is observed as the temperature increases up to 800 °C, after that the desilication of zircon gradually increases. Above 900 °C, the temperature has no effect on the efficiency of sintering.

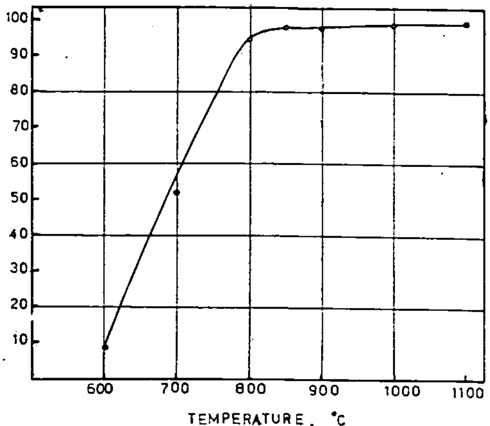

Fig. 3

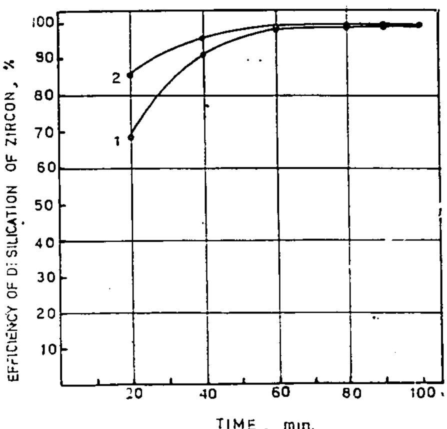

Fig. 4

3. At short time of sintering, the desilication of zircon is low. This is due to the fact that the reaction of sintering of zircon with aluminum fluoride takes place in solid state. This needs a long time for contact of solid reactants and also their preliminary complete mixing.

4. At 850°—900 °C, complete desilication of zircon takes place during 1 hour. Longer time more than 1 hour has little effect on desilication of zircon, i has some influence on the growth of the crystalline products of sintering, namely baddeleyite and corundum.

From the results obtained, the optimum temperature, at which complete desilication of zircon occurs, can be considered as 850 °C at duration 1 hour.

Study of the products of desilication of zircon with aluminum fluoride

The reaction of sintering of zircon with aluminum fluoride in presence of graphit results in the formation of baddeleyite and corundum.

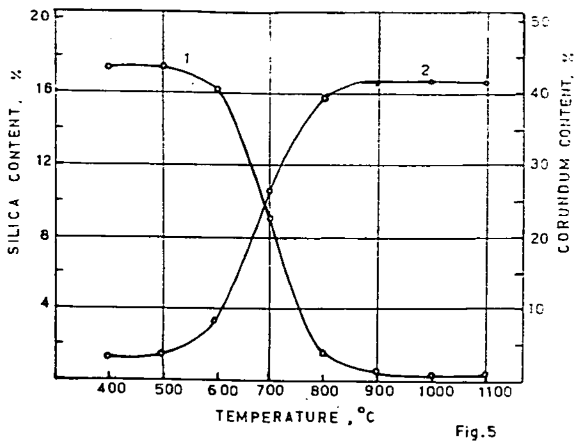

Fig.5

From *Fig. 5*, it is shown that the amount of combined silica in the chemical composition of zircon sharply decreases in the product of sintering as the temperature increases. It is observed that the desilication of zircon takes place intensively above 650 °C. Its complete desilication occurs at 850 °C, where the silicon content of the end product of sintering shows a minimum value.

Formation of corundum

The relation between the corundum content in the product of sintering and the temperature is shown in *Fig. 5*. It is observed that the amount of corundum sharply increases as the temperature increases from 600° to 800 °C. Above 850 °C, it reaches a constant value and the reaction of corundum formation takes place completely.

Formation of baddeleyite

Fig. 6 shows the relation between zircon content in the initial mix and baddeleyite content in the sintering product and temperature. The amount of zircon sharply decreases (opposite case, baddeleyite) at temperature range 600°—800 °C. At 850 °C, the amount of baddeleyite reaches a high value and there is no change of its content at higher temperature. At the same time, the zircon content reaches minimum. By microscopic examination of thin sections of the end product of sintering at 850 °C, it is observed that only few relict zircon grains are detected. The whole mass of the section consists of baddeleyite and corundum.

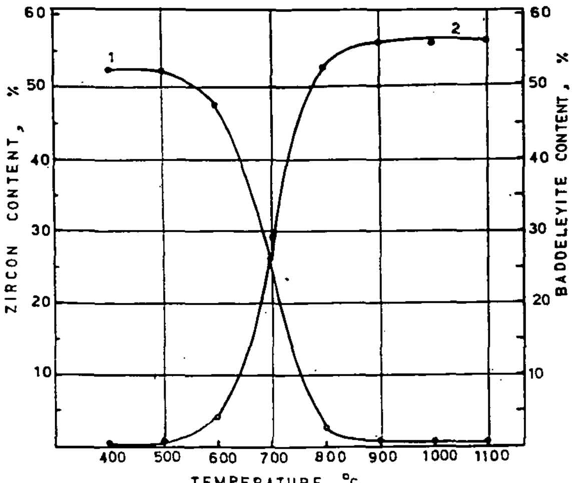

Fig.6

The product of zircon sintering with aluminum fluoride were studied microscopically. The product obtained at 650 °C consists mainly of zircon with few corundum and baddeleyite grains. At 700 °C, it is composed of zircon and baddeleyite-corundum

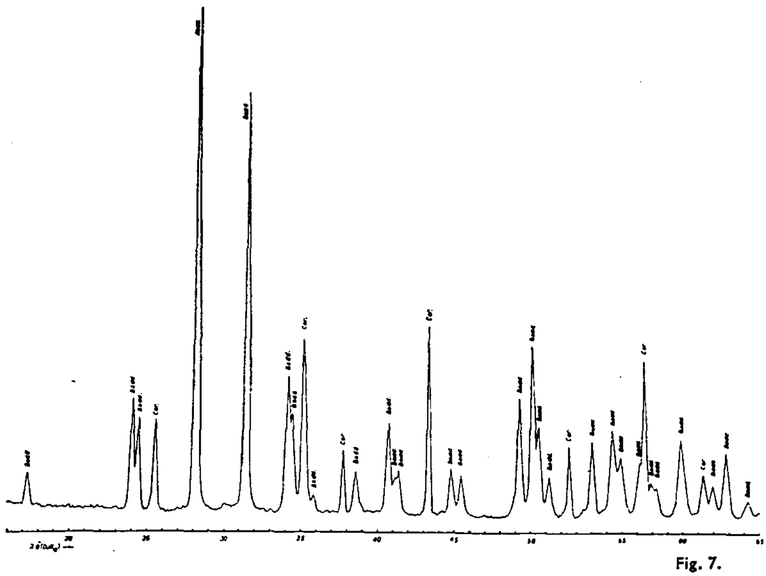
Fig. 7.

in approximately equal amounts. As the temperature increases, the amount of zircon decreases, till it reaches minimum. At 850°—900 °C, baddeleyite and corundum constitute the total composition of the end product of sintering with few fine relict zircon grains. Baddeleyite and corundum show simultaneous crystallisation. They have different crystal forms, elongated, tabular, rounded and irregular form. Corundum appears colourless, with very high relief, non cleavage, moderate birefringence and optically uniaxial negative. Some grains show striations.

Baddeleyite appears pale yellow, with high relief, showing poor cleavage and optically biaxial negative.

The grain size of the obtained refractory material depends upon temperature and time of sintering. At 850 °C, and 1 hour, the grain size ranges 0.05—0.15 mm.

The X-ray diffraction patterns of the end product of sintering *(Fig. 7)* shows only the peaks of baddeleyite and corundum. They are intense and narrow, suggesting good crystallinity. Zircon peaks are completely disappeared, indicating its absence.

The unit cell dimensions and constants of the artificial baddeleyite and corundum are given in Table 4. Baddeleyite ctystallises in monoclinic system, while corundum crystallises in hexagonal system. It is observed that the calculated cell dimenisons, constants and optic axial angles of the synthetically formed baddeleyite and corundum are consistent with the corresponding data of the natural minerals.

TABLE 4

Unit cell dimensions and axial angles of baddeleyite and corundum

Mineral	No. of lines used	a Å	b Å	c Å	α deg. min.	β deg. min.	γ deg. min.	V Å^3
Baddeleyite (Monoclinic)								
Synthetic	23	5.2458 ±0.0611	5.2030 ±0.0769	5.2849 ±0.0722	90 0.00	80°48' ±1.051	90 0.00	142.26 ±0.01
Standard		5.26	5.21	5.37	90	80°36'	90	
Corundum (Trigonal)								
Synthetic	8	4.7424 ±0.0109	4.7424 ±0.0109	12.9807 ±0.0209	90 0.00	90 0.00	120 0.00	252.83 ±0.004
Standard		4.751	4.751	12.98	90	90	120	

The behaviour of zircon has been studied under different sintering conditions with aluminum fluoride in presence of graphite. It is found that the sintering process results in the production of monoclinic baddeleyite and hexagonal corundum.

Rosetta zircon is optimally desilicated with the formation of baddeleyite at 850 °C and time 1 hour, using zircon mixes with aluminum fluoride and graphite at ratio 1:0.8:0.1, respectively. Under these conditions, the efficiency of desilication of zircon reaches 98.8%. The end product of sintering (with silica content 0.37%) is a refractory material of zirconium and aluminum oxides, which is useful for many industrial purposes.

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A NEW BARITE OCCURRENCE AT EL FAWAKHIR AREA, EASTERN DESERT, EGYPT

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ABSTRACT

A new barite occurrence in El Fawakhir area of the central Eastern Desert is to be reported for the first time. This barite occurs in the form of veins occupying a shear zone emplaced along the contact aureole between El Fawakhir granite mass and the surrounding metamorphic rocks. The studied barite is well crystalline forming crystal aggregates and is almost pure with minor calcite content. It is proposed that there may be a genetic relationship between barite formation and the enclosing granitoid rocks.

INTRODUCTION

This new occurrence of barite mineralization lies approximately at the intersection of longitude 33° 38 E and latitude 26° 02 N, in the central Eastern Desert of Egypt. It is located at about four kilometers to the northeast of El Fawakhir Gold Mine along Qift-Qusseir road. It has a distance of about 90 km due west from Qusseir on the Red Sea, and also about 90 km due east from Qift on the River Nile.

Although the surrounding area has been the center of successive exploration and mining activities since the Ancient Egyptians, particularly for gold, yet no barite mineralization had been recorded or mentioned in any of the various published works on this area.

On the other hand, on reviewing the available literature on the Egyptian mineral deposits including those devoted for barite, again no mention was found concerning barites from El Fawakhir area. Thus, SADEK [1953] reported several thin veins of barite in the granitic rocks south of Kab El Gallaba, south Eastern Desert. SABET and ZAATOUT [1955] recorded some barite veins filling the fissures in Gebel El Bakriya pink granite mass in El Barramiya area.

EL SHAZLY [1957] referred to the rarity of barite veins in the Eastern Desert of Egypt, and he classified them among the true hydrothermal fissure veins. MOHARRAM [1959] mentioned some barite deposits in the Eastern Desert and Bahariya Oasis. NAKHLA and EL HINNAWI [1960] studied some important barite occurrences in both the Eastern and Western Deserts. SAID [1962] emphasised the presence of some barite occurrences in east Aswan area and other localities in the Eastern Desert. EL SOKKARY [1963] reported the presence of barite mineralization in association with the Carboniferous dolomites and accompanying Fe—Mn ores of west central Sinai.

AWAD [1967] in an M. Sc. thesis studied the geology and mineralogy of some barite and celestite occurrences in Egypt with special emphasis on barites from east Aswan, Bahariya and celestite from Mokattam. More recently, MOHARRAM *et al.* [1970] on their study on some mineral deposits from Egypt reviewed the status of Egyptian barites.

The present paper presents the new occurrence of barite mineralization recorded to the first time in this area of the central Eastern Desert of Egypt. The study concerns mainly with the mode of occurrence, field relations between the mineralization and the surrounding country rocks, radiometric studies as natural tracers beside some mineralogical investigations of the ore samples representing this occurrence, irrespective of its economic potentialities.

FIELD OCCURRENCE

The barite occurrence at El Fawakhir locality is found to be generally connected with highly metamorphosed rocks along the north-eastern marginal zone of El Fawakhir granite mass. The mineralization occurs filling a shear zone within the contact aureole between the older serpentinite rocks and the hybrid rocks of highly granitized metavolcanics and epidiorites which are intensely effected by the younger granitic intrusion.

The found occurrence of barite mineralization is not continuously exposed on the surface, but it has been followed along the mentioned shear zone with some irregular and discontinuous manifestationson the surface, while the vein itself can be followed at shallow depths. The barite occurrence forms a main vein of about 20—30 cm width and extends for more than 300 m in a general trend of N 20°—25° W—S 20°—25° E dipping moderately 35°—50° to the south west. Other minor and very thin veins are occasionally found within the shear zone which attains a thickness ranging from 50 to 100 cm. However, detailed field investigations and some prospecting works are needed to explore other occurrences in the surrounding area, as well as to follow the extension of the present occurrence and to evaluate it.

Field measurements of radioactivity were carried out by means of a scintillometer on the barites as well as on the surrounding rock units which gave the following results: serpentines gave from 5—7 μR/h, epidiorite — granitized metavolcanics 10—15 μR/h, pink granites 20—25 μR/h, younger acid dykes 40—50 μR/h, while the shear zone including the barite veins gave a range of 12—15 μR/h. It is seen that the range of radioactivity of the shear zone including the barites is similar to that of the granitized rocks, a matter which may indicate a genetic relation between barite formation and the process of granitization in this area. Moreover, the presence of barites filling fissures and cracks in a shear zone may point towards a hydrothermal phase following the emplacement of granite.

MINERALOGY

This barite of El Fawakhir occurrence is of whitish coloration, sometimes with yellowish stainings, and looks opaque in hand specimens. It includes two main varieties, one hard and the other is friable. It is generally well crystalline and the crystals form aggregates with a tabular habit, sometimes massive. Individual crystals have average dimensions of 2—4 cm, while in certain cases they can reach about 10 cm, finer sizes are present also. Cleavage traces are perfect in one direction.

With respect to specific gravity, twelve determinations are made on different samples. The determined specific gravity of the studied barite samples ranges from 4.32 to 4.37 with an average of 4.34. This average is close to the specific gravity of the standard barite which ranges between 4.3 and 4.6 [DANA, 1949] indicating the almost pure nature of the studied barite. The hard variety seems to show a slightly higher specific gravity of 4.36 relative to the friable variety which shows a somewhat lesser value of 4.32. This lower value of specific gravity is attributed mainly to the presence of some fractures and alternation earthy material.

Calcite is present as minor impurity associated with barite, nevertheless its distribution is not quite homogenous. Fluorescence test with an ultraviolet lamp on the studied samples of barite did not reveal any characteristic fluorescence. No fluorite is associated with this type of barite.

CONCLUSIONS

The present communication deals with a new discovery of barite veins in El Fawakhir area of the central Eastern Desert. This barite is associated with granitic rocks and in this way is to be added to the growing list comprising the association of barite with granitic rocks in the Eastern Desert, *e. g.* Gebel El Hudi area, Gebel El Bakriya, Wadi Hamash and others. CLARKE [1959] reported a case in which barite vein cuts through a dyke of augite diorite. International association of barite veins with granites are mentioned in some detail in DEER *et al.* [1962]. However, the problem of association of barite veins with granitic masses needs further investigation as to the origin and mode of formation of these barites. Mineralogically, El Fawakhir barite can be considered as a pure variety with minor calcite as gangue.

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A FLUORITE-CALCITE MINERALIZATION AT WADI UM ESH EL ZARQA, CENTRAL EASTERN DESERT, EGYPT

A. A. EL SOKKARY and I. A. EL KASSAS

ABSTRACT

A fluorite-calcite mineral association is to be reported and studied to the first time at Wadi Um Esh El Zarqa in the central Eastern Desert. This is a fissure filling vein deposit occurring in a country of dioritic and amphibolitic rocks. The vein is trending generally N—S and is 1.20 ms width and about 400 ms in length. The fluorite has a mean specific gravity of 3.16, while the calcite has an average gravity of 2.72. The fluorite is altered to calcite. It is shown that the investigated flourite is formed most probably during a main pneumatolytic process and not during a hydrothermal phase.

INTRODUCTION

A fluorite-calcite mineral association is occurring at Wadi Um Esh El Zarqa east of Wadi Atalla El Murr which is an eastern branch of the main Wadi Atalla. It is located at about 15 kms to the north of El Fawakhir Gold Mine on the Qift-Qusseir asphaltic road in the central Eastern Desert of Egypt. It lies at the intersection of longitude 33° 37 E with latitude 26° 08 N.

As a matter of fact, recorded fluorite occurrences in Egypt are relatively few in number and the study of fluorite mineralization did not receive adequate attention up till now.

HUME [1937] stated that fluorite is found in talc schists adjoining tin-bearing quartz veins situated at about six kms to the north east of Gebel Muweilih. SADEK [1953] reported the presence of fluorite in small quantities in quartz veins in the gneisses of Wadi Sikait belonging to Wadi Gemal area in the south Eastern Desert. ABDEL NASSER and CHUKRI [1954] during their prospecting and exploration in south Sinai found a small fluorspar vein near Wadi Seih Sidri surrounded on both sides by a white calcite vein.

MOUSTAFA *et al.* [1954] recorded some fluorite mineralization occuppying the middle part of quartz veins cutting through the Pink-red granite mass of Gebel El Ineigi. This fluorite is associated with few scattered grains of galena and minute specks probably of chalcopyrite. AMIN [1955*a*, *b*] mentioned the presence of fluorite either as separate veins or as one of the constituents of the mineralized veins in association with the tin = tungsten deposit in Wadi Igla. EL SHAZLY [1957] considered the tin-tungsten veins-with the associated fluorite mineralization-such as that at El Muweilha locality, to be of the hypothermal call among the true hydrothermal fissure veins of a late precambrian age.

MOHARRAM *et al* [1970] reviewed the ststus of fluorite occurrences in Egypt and referred to its presence at El Ineigi and Igla localities. EL SOKKARY [1970] reported the presence of fluorite as accessory mineral associated with some pink-red granites in the Eastern Desert and Sinai peninsula. Other minor occurrences are said to be reported in other localities of the Eastern Desert e. g., Homret Akarem and Homret Waggat.

The present work represents the first detailed investigation on the fluorite-calcite mineralization at Wadi Um Esh El Zarqa from the geological and mineralogical points of view.

GEOLOGICAL SETTING

The fluorite occurs banded with calcite in a manner that fluorite is in contact with country rock. The two mineral association forms a fissure vein deposit of about 1.20 m width with a surface exposure of about 400 m in length. It is emplaced along a fault zone of some two km extension and about 10 m width of alteration. The fault is trending generally N—S and is steeply dipping (60°—70°) to the east. It is passing through a country of dark greyish green, medium grained dioritic rocks and granitized amphibolites that are intruded by numerous dykes of aplites, felsites and microgranites beside numerous quartz veins. The lower parts of the amphibolite are highly foliated with a trend of foliation roughly running N—S.

There is a sort of quartz body taking a lensoid shape, extending about five meters in length and has a variable thickness ranging between 50—150 cm and taking a N—S direction. It is milky white in color, but tends to be reddish and striated on the fractured and weathered surfaces.

Field measurements of gamma radioactivity by a scintillometer gave a range from 6—8 μR/h for amphibolites while the mineralized vein gave an activity from 10—12 μR/h. It is seen that the mineralized vein shows a slightly higher activity than that of the surrounding rocks.

MINERALOGICAL INVESTIGATION

This occurrence consists of apple green fluorite occupying a band of about 8—10 cm thick. The color varies from deep apple green to paler shades and sometimes almost colorless. The fluorite crystals form aggregates that are massive. Individual crystals can reach up till 2.5 cm in length. Associated with this fluorite, there are some calcite which sometimes take the form of small veins or veinlets of about 0.7 cm thick. The latter follow cracks and fissures in the fluorite and hence calcite is later than fluorite in its paragenetic sequence. Veins and veinlets may be straight or irregular. The rock is subjected to intense cracking and hence to deformation.

Fluorite crystals are sometimes observed to give reaction with HCl which means that they are associated with fine calcite particles probably occupying very thin veinlets, a matter which may prove that calcite is an alteration product of the fluorite. CLARKE [1959] states that fluorite alters into calcite, being attacked by percolating waters containing calcium bicarbonate or alkaline carbonates.

Specific gravity measurements are done on eight separated samples of fluorite crystals and gave a range of 3.14—3.18 with an average of 3.16. This average is close to that of crystallised fluorite which is 3.18 [DANA, 1949]. However the slight lowering of specific gravity of the investigated fluorite may indicate its alteration to a limited extent.

Calcite band on the other hand occupies about 5 cm in width. It is composed of massive well crystallised calcite with almost white color tinted with pale violet shades. Most of the crystals have an average size of about 3 cm but some can reach up till 4 cm. Calcite crystals develop good rhombic cleavage. They give strong and instantaneous effervescence with HCl proving that they are calcite and not dolomite.

The calcite block contains small veinlets always along cracks that are full with dark and hard material which does not give always positive reaction with HCl and may be in its most part silica (quartz).

Another eight measurements of specific gravity are done on some separated crystals of calcite. They gave a range of 2.72—2.74 with an average of 2.72 which is close to that of pure crystallised calcite with specific gravity of 2.71 [DANA, 1949]. Under ultraviolet light, fluorspar shows a characteristic deep violet fluorescence, while calcite glows with a brilliant rosy fluorescence.

Specks of steel black galena are present occupying small fissures in the fluorite. They give the smell of H_2S on treating with HCl. Thus galena, like calcite, follow fluorite in the paragenetic sequence, but its relative order to calcite is not quite clear.

DISCUSSION

The fluorite-calcite mineral association is present in the form of a vein which is emplaced along a fault zone trending generally N—S. This vein is running into a country of dioritic and amphibolitic rocks. Whenever these rocks are foliated, they take a trend of foliation roughly running N—S. The vein is thus originally occupying preferentially a prominent foliation plane in the surrounding country rocks which was augmented later by faulting. Therefore, this type of vein is most probably of the fissure filling type.

The slight increase of the radioactivity of the vein over that of the surrounding rocks might indicate that the material of the vein, at least partly, is not from quite extranaceous sources. Possibly the original basic country rocks had provided the necessary Ca for making the fluorite during an alteration process. If this alteration occurs during a pneumatolytic phase accompanied by fluorine emanation, then fluorite will be formed. This pneumatolysis is justified since the country rocks were subjected to granitization and intrusion of numerous acid dykes i.e. they were subjected to igneous activity. Later on, the fluorite partly gave to calcite by alteration. Thus fluorite here is formed most probably during pneumatolysis and not during a hydrothermal phase. CLARKE (1959) mentioned that fluorine compounds are especially characteristic of the deep-seated or plutonic rocks, where the gaseous exhalations have been retained under pressure, and are commonly regarded as of pneumatolytic origin.

However, a later mobilizing hydrothermal phase can be postulated, following the main pneumatolytic process, which might be responsible for filling the fissure vein. DEER *et al.* [1972] mention that in the igneous fluorite occurrences associated minerals include cassiterite, topaz, apatite, lepidolite, etc., for the pneumatolytic deposits and calcite, pyrite, apatite, etc., for the hydrothermal product. The same authors add (p. 513) that fluorite is often found associated with typical hydrothermal minerals not known to be directly related to any igneous body. Such hydrothermal vein deposits may also carry barytes, sphalerite, galena, calcite and chalcedony or quartz.

Accordingly, the presence of calcite, galena and quartz in association with the investigated fluorite may indicate the possible presence of a hydrothermal phase involved in its formation.

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LETTERS OF THE COMMISSION ON MANGANESE (IAGOD)

REPORT ON THE 2ND INTERNATIONAL SYMPOSIUM ON THE GEOLOGY AND GEOCHEMISTRY OF MANGANESE

organized by the IAGOD Commission on Manganese, sponsored by the IGCP and IUGS
25th JGC, August, 1976, Sydney, Australia

by I. M. VARENTSOV
Secretary, Comission on Manganese

In the progress of Geosciences during the last decades the advances in the studies of geology and geochemistry of manganese and associated transitional metals take the proper place. The findings of large deposits of the manganese ores in Australia, Africa and South America as well as huge accumulations of manganese, nickel, cobalt, copper and other economically valuable metals in certain regions of the World Ocean can be regarded as evidences.

The 1st International Symposium on broad aspects of geology and in a lesser degree on the mineralogy and geochemistry of manganese was held during the 20th International Geological Congress in 1956 in Mexico.

The IAGOD Commission on Manganese at its Business Meeting in 1970 in Tokyo — Kyoto decided to organize the 2nd International Symposium on the Geology and Geochemistry of Manganese in 1976 during the 25th IGC and to publish the Proceedings of the Symposium in form of an International Monograph.

The main goal of the 2nd International Symposium on the Geology and Geochemistry of Manganese was to summarize and discuss the advances in these areas reached in the last twenty years period, focussing the attention to the following three main topics:

Section I: Geology of manganese deposits on the continents;
Section II: Problems of geochemistry and mineralogy of manganese;
Section III: Manganese on the bottom of Recent Basins.

During the organization of the Symposium the necessary and useful co-ordination with other bodies of the IUGS was established: e. g. with the IUGS Commission for Marine Geology (Prof. DR. E. SEIBOLD, University of Kiel, FRG). It was decided to organize a joint session of the Symposium on Geology and Geochemistry of Manganese and the Symposium on the Economic Geology of the Sea Floor (fuels excluding).

In preparing the Symposium on Geology and Geochemistry of Manganese the officers of the IAGOD Commission on Manganese as well as the conveners of the sections played the major role.

57 contributions from 13 countries were submitted for the Symposium on the Geology and Geochemistry of Manganese (see 25th IGC Abstracts vol. 3, Symposium 104.3, pp 759—801). 36 papers covering the principal areas of geology, geochemistry and mineralogy of manganese were selected for oral presentation. The papers will be published in the Monograph on the Geology and Geochemistry of Manganese, in 1977 by the Publishing House of the Hungarian Academy of Sciences in co-operation with the Schweizerbartsche Verlagsbuchhandlung (Stuttgart, FRG).

Section I: Geology of Manganese Deposits on the Continents

Convener: SUPRIYA ROY (India)

11 papers were presented and discussed on the results of the studies on manganese deposits of Australia, Africa, South America, Japan and India.

The most interesting papers dealt with the geology, mineralogy and genesis of manganese deposits of North Australia (Groote Eylandt Manganese Deposits), Central West Africa (Moanda Manganese Deposit, Gabon; Nsuta Manganese Deposit, Ghana). These deposits belong to the type that has not been known well: lateritic concentration of primarily poor accumulations of manganese. This process leads to formation of huge deposits of high grade manganese ores, the reserves being evaluated as hundreds of million tons.

The prominent paper was presented by S. ROY, Professor of Geology (Jadavpur University, Calcutta, India): „Certain Genetic Problems of Manganese Deposits". The paper suggests some subdivisions of manganese deposits on the basis of data on the recently investigated ore-bearing regions of India, Africa, South America and the present-day-basins.

Section II: Geochemistry and Mineralogy of Manganese

Conveners: R. GIOVANOLI (Switzerland)
R. BURNS (USA)
R. SOREM (USA)

15 papers were discussed at the Section II. Mineralogical papers were delivered by R. G. BURNS (USA), F. V. CHUCKROV (USSR), R. GIOVANOLI (Switzerland), R. K. SOREM (USA) and others. All these papers can be regarded as a new stage in the study of the very complex compounds — oxide, hydroxide minerals — of manganese, iron and associated transitional metals. These studies were carried out on the up-to-date level: structural-crystallochemical researches with wide utilization of methods of modern instrumental analysis.

The geochemical problems were treated in papers presented by K. BOSTRÖM (Sweden), C. LALOU *et al.* (France), R. M. MCKENZIE (Australia), J. C. MILLS *et al.* (Australia), K. H. WEDEPOHL (FRG).

The remarkable feature of papers on geochemistry of manganese is the use of informations obtained by the methods of modern instrumental analysis for many components aimed at the understanding of the natural processes. Noteworthy is a predominant tendency to create the global system of the geochemical patterns of distribution of manganese and associated metals. The paper by K. BOSTRÖM shows that the volcanic processes of the Mid-Oceanic Ridges and the fracture zones play an essential role in the accumulation of manganese ores in the World Ocean. The paper by K. LALOU *et al.* was listened to with special attention. It was shown by radioisotopic dating (^{230}Th, ^{14}C) that the rate of growth of ferromanganese nodules of the abyssal parts of the World Ocean is some orders higher than it was estimated previously. The conclusions allow us to explain the existence of huge accumulation of manganese ores of economic value formed during the Quaternary period.

The scientific and practical significance of the presented geochemical papers is that they are the first attempts to create the genetic approaches which are adequate well enough with the real natural conditions in all their diversity. It is evident that, having such scientific background and knowing the factors controlling the ore formation, the geologists will be able to obtain in the nearest future a tool for identification of regions promissing for ore accumulations of manganese, nickel, cobalt and other metals.

Section III: Manganese on the Bottom of Recent Basins

Conveners: E. SEIBOLD (FRG)
D. S. CRONAN (U. K.) (Joint Session)
I. M. VARENTSOV (USSR)

10 papers were presented and discussed at the session. As it was mentioned above, this section was a joint session with the Symposium of IUGS Comission for Marine Geology, entitled „Economic Geology of the Sea Floor" (fuels excluding). The main task of the section was to discuss the major reviewing papers summarizing the present-day state of investigations of mineral deposits on the bottom of recent basins. Papers were discussed on the progress in the U. S. Interuniversity Manganese Nodule Project by E. J. DASCH and E. GERARD (USA); on the Red Sea metalliferous muds by M. SCHOELL and R. D. BIGNELL (FRG); on ferromanganese ore accumulations in shallow-water basins by I. M. VARENTSOV (USSR); on the comparison of processes leading to concentration of economically valuable metals in metalliferous sediments and nodules by H. BAECKER (FRG) and D. S. CRONAN (U. K.); on technical problems in ocean mining by J. P. LENOBLE and G. PAOTOT (France). Reviewing papers were also discussed: on the geology and genesis of placer deposits in the sea (Australia, New Zealand, S. E. Asia); on genesis of the oceanic phosphorites by P. L. BEZRUKOV and G. N. BATURIN (USSR).

The papers delivered and their discussion showed that the World Ocean contains great resources of ores. The preliminary mining of ores has been started, and in the nearest future the mining companies of the industrially developed countries will be able to mine rich abissal ore accumulations.

The scientific and practical importance of the papers discussed at the Symposium lies in summarizing the advances of the studies of wide aspects of geology and geochemistry of manganese for the las 20 years' period. These papers and the others submitted will be published in volumes of the Monograph on the Geology and Geochemistry of Manganese. This book will inform the geologists of the World on the important achievments in this field of sciences.

REPORT ON THE ORGANIZATIONAL MEETING OF THE IGCP PROJECT NO. 111 GENESIS OF MANGANESE ORE DEPOSITS, AUGUST 22, 1976, SYDNEY

by IGOR M. VARENTSOV
Secretary, IAGOD Commission on Manganese

Chairman: PROF. GY. GRASSELLY, President of the Commission on Manganese
Secretary: IGOR M. VARENTSOV, Secretary of the Commission on Manganese
National representatives:

Australia: R. M. MCKENZIE, I. W. REID, K. J. SLEE, W. C. SMITH
Brazil: EVARISTO RIBEIRO FILHO
Hungary: GY. GRASSELLY
India: SUPRIYA ROY
New Zealand: G. GLASBY
Roumania: the head of the delegation
S. Korea: SOO JIN KIM
Sweden: K. BOSTRÖM
Switzerland: R. GIOVANOLI
USA: R. G. BURNS, P. A. RONA, R. K. SOREM
USSR: I. M. VARENTSOV

Many participants of the IGC were also attending the Meeting.

GY. GRASSELLY, President of the Commission on Manganese in his presidential address reported that the IAGOD Commission on Manganese proposed to the IGCP Board the project: Genesis of Magnese Ore Deposits. The IGCP Board accepted the project under category A, No. 111, priority area 4. PROF. GRASSELLY emphasized the importance of a well organized and co-ordinated international co-operation in the research work itself not only in organizational work.

On October 1, 1975 the IAGOD Commission on Manganese forwarded the 1st Circular with the information on the Project No. 111 to National Committees on Geology as well as IGCP National Committees of more than 80 countries. Responses from many countries have been received. In these responses also the necessity of the co-operation and the readiness to co-operate are expressed.

I. M. VARENTSOV proposed for discussion the following agenda:

1) Consideration of the fundamental idea of the project and subject areas
2) Structure of the project and election of officers.
3) Mechanism of co-operation and the further plans.
4) General discussion.

The items on the agenda were accepted.

ad 1) I. M. VARENTSOV, Secretary of the Commission stated that the IAGOD Commission on Manganese is the base on which the Project can be started. The Commission is an international body with many experiences on co-ordination of international researches in this area of geology. At present, the Commission united the leading scientists in geology, mineralogy and geochemistry of manganese. This can be evidenced by the 2nd International Symposium on the Geology and Geochemistry of Manganese. It should be born in mind that the real tasks of the project cover not only the problems of the geology and the genesis of manganese ore deposits, they should be regarded as a broad theme: Manganese and other transitional metals in the Earth's crust.

The experiences in the international researches on the wide aspects of geology f manganese and the preliminary evaluation of the possiblities of the researchers of ifferent countries ready for participation in the common work allow to outline he main subject areas of the project.

PANEL I

Geology and genesis of manganese deposits on the continents

Within this panel the following major themes can be outlined:

I/a Geology and genesis of volcano-sedimentary manganese deposits.
I/b Geology and genesis of manganese deposits of the weathering crust.
I/c Geology and genesis of Precambrian manganese deposits.

PANEL II

Problems of mineralogy and geochemistry of manganese and associated transitional metals

The following major themes can be outlined within this panel:

II/a Genetical problems of manganese mineralogy.
II/b Manganese and transitional metals in natural waters.
II/c Geochemistry of the processes of manganese ore formation (experimental studies and investigation of natural phenomena).

As the themes outlined are of principal and general character the collaboration of the researchers within this panel should be of close international co-operation.

PANEL III

Mangenese and associated metals on the bottom of recent basins

Is seems appropriate to outline some themes within this panel:

III/a Manganese on the bottom of Mediterranean and shelf basins.
III/*b* Geochemistry of manganese ore accumulations (metalliferous sediments, nodules) related with volcanism in the World Ocean.
III/c Formation of manganese ores in the regions of the Pacific Ocean: South-Western regions.
III/d Processes of development of the axial zones of the World Ocean with special reference to formation of ore accumulation of manganese and associated metals.
III/e Study of mineral composition and texture of the nodules of the great accumulations of manganese ores in the World Ocean as a method to learn the history of formation.
III/f Geochemistry of ore formation of manganese and the assoFiated metals in the transition zone: ocean — continent.

The participants discussed and adopted the subject areas mentioned above. In the detailed talks (S.Roy, India, R. Giovanoli, Switzerland, K. Boström, Sweden, D. S. Cronan, U. K., R. Sorem, USA, and others) constructive suggestions and remarks were done which particularly specify the real possiblities of the forthcoming researches.

ad 2) The participants discussed and accepted that the Staff of the Project consists of

Project leader (the President of the IAGOD Commission on Manganese).

International co-ordinator (the Secretary of the IAGOD Commission on Manganese).

Heads of the Project panels and working groups, resp.

After discussion of the suggested proposals the following persons were elected as leaders of the Project and the Panels and Working Groups, respectively:

Project leader: GYULA GRASSELLY (University, H-6701 Szeged, Pf. 428, Hungary).

Co-ordinator of the Project: IGOR M. VARENTSOV (Geological Institute, USSR Acedemy of Sciences, Pyzhevskiy pereulok 7, 109 107 Moscow, Zh—17, USSR).

Leaders of the panels:

Panel I: SUPRIYA ROY (Dept. of Geol. Sci., Jadavpur Univ., Calcutta-32, India)

Panel II: R. GIOVANOLI (Laboratorium für Elektronen-Mikroskopie, Universität Bern, Postfach 140, CH-3000, Bern 9, Switzerland).

Panel III: K. BOSTRÖM (Dept. of Econ. Geol., University of Lulea, 95 187 Lulea, Sweden).

Leaders of the working groups (subdivisions):

III/a K. BOSTRÖM (address shown above).

III/b D. S. CRONAN (Dept. of Geology, Royal School of Mines, Imperial College of Science and Technology, Prince Consort Road, London SW 7, 2 BP, U. K.).

III/c G. P. GLASBY (New Zealand Oceanographic Institute, P. O. Box 12-346, Wellington North, New Zealand).

III/d P. A. RONA (National Oceanic and Atmospheric Administration, 15 Rickenbacker Causeway, Miami, Florida 33 149, USA).

III/e R. K. SOREM (Dept. of Geology, Washington State University, Pullman, Washington 99 163, USA).

III/f R. G. BURNS (Dept. of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA).

In the discussion it was emphasized that the number of Working Groups can be changed depending on those problems which can arise in the future and are worthy to be included into the project.

ad 3) The work within the panels and working groups is carried on by the researchers co-ordinated by the heads of the working groups. The solution of principal problems of the Project, the organization of meetings, coordination of the work among the panels and working groups are carried on by the international co-ordinator and the project leader, respectively.

Between the sessions the current affairs are considered and co-ordinated by correspondence. The major problems (including the financial policy, distribution of funds, etc.) should be discussed at the session of the Project.

The leaders of the Working Groups of the Project are kindly requested:

a) To outline the detailed scientific and business programme of the activity of the Working Group. The programme should contain information on the following items:

Scientific task and objectives

Methods

Field and laboratory researches
Meeting and joint excursions
Schedule of the work

b) The organizations and individuals interested should be widely informed and invited to take part in the research work according to the suggested programme.

c) After consideration of comments received the leaders are requested to compile the detailed programme of the Working Group.

This detailed programme should contain the following items:

1) title of the theme (subdivision, working group),
2) name of the Working Group leader,
3) official contact address,
4) list of participating organizations, researchers,
5) principal decisions expected to be taken, especially with reference to the original objectives of the Project subdivision (theme), their expansion and modification,
6) the foreseeable field and laboratory researches,
7) the foreseeable meetings, excursions etc.

d) To inform currently the Project co-ordinator about the progress in the realization of the subdivisions programme.

Please, to present the final programme to the co-ordinator within 6-months period.

The next session of the IAGOD Commission on Manganese and the IGCP Project No 111: „Genesis of Manganese Ore Deposits" is planned to be held in 1978, in Salt Lake City, USA within the frame of the IAGOD Symposium .However, it seems reasonable to consider the possibility to organize a meeting within the Second Symposium on the Origin and Distribution of the Elements — Paris — UNESCO, May 10—13, 1977. Some sections of this Symposium may be of common interest and the meeting would offer a good possibility to discuss the detailed programme of the Project subdivisions.

ad 4) The participants whole-heartily adopted the beginning of the Project. It was noted that at present time the solution of the manyfolded problems of geology and geochemistry of economically valuable metals could be managed only on the basis of an international collaboration. The scientists of the different countries only under these conditions can exchange the scientific informations, the experiences. The participants asked the Co-ordinator of the Project to compile a preliminary report on this meeting and to distribute it among the organizations and individuals interested.

It was decided to publish the reports on the 2nd International Symposium on Geology and Geochemistry of Manganese, on the Business Meeting of the IAGOD Commission on Manganese as well as on the IGCP Project Meeting in the „Acta Mineralogica—Petrographica Universitatis Szegediensis", Szeged, Hungary.

All the organizations and individuals are requested to submit their proposals and comments to the leaders of the Project.

REPORT ON THE BUSINESS MEETING OF THE IAGOD COMMISSION ON MANGANESE

August 22, 1976, Sydney, Australia

IGOR M. VARENTSOV
Secretary, Commission on Manganese

Chairman: GY. GRASSELLY, President of the IAGOD Commission on Manganese.
Secretary: I. M. VARENTSOV, Secretary of IAGOD Commission on Manganese.
Participants: R. M. MCKENZIE, A. R. MILNES, I. W. REID W. C. SMITH, K. J. SLEE (Australia), EVARISTO RIBEIRO FILHO (Brazil), GY. GRASSELLY (Hungary), T. WATANABE (Japan(, SUPRIYA ROY (India), G. GLASBY (New Zealand), SOO JIN KIM (S. Korea), K. BOSTRÖM (Sweden), R. G. BURNS, P. A. RONA, R. K. SORON (USA), I. M. VARENTSOV (USSR) and others.

1. The Chairman addressed with an introductory talk; he wellcomed the participants — representatives of 11 nations on behalf of the Officers of the IAGOD Commission on Manganese and IUGS.

After a brief discussion the participants accepted the agenda of the Meeting.

2. According to the agenda I. M. VARENTSOV presented a report on the previous activity of the IAGOD Commission on Manganese. It was stated that at the 1st Business Meeting of the Commission on Manganese, 1970, Tokyo—Kyoto was decided to organize the 2nd International Symposium on Geology and Geochemistry of Manganese within the 25th International Geological Congress and to publish the International Monograph-Proceedings of the Symposium. During 6-years period the Commission on Manganese held scientific and business meetings: 1972, Montreal, Canada, 24th IGC; 1974 — Golden Sands — Varna, Bulgaria, IAGOD Symposium. At these sessions the state and advances in preparations of the 2nd International Symposium on Geology and Geochemistry of Manganese were discussed. At the scientific sessions of the Commission the papers that could be mostly considered as the parts of some works were discussed. These works were subsequently submitted for the Monograph.

All the previous activity of the Commission on Manganese were focussed to reach the main goal: organization of the 2nd International Symposium on Geology and Geochemistry of Manganese. This Symposium can be regarded as a prominent event in the International activity of the Commission, united the leading specialists of the World in this field of science.

The activity of the Commission can be evidenced by a steady increasing of the submitted papers of the proper scientific significance at three sessions:

1970. Tokyo—Kyoto, Japan. It was discussed 6 papers presented by the specialists from 5 countries. The abstracts and the papers were published in the Proceedings of the joint IMA—IAGOD Session, Japan.

1972. Montreal, Canada. 8 papers presented by specialists from 4 countries were discussed; the abstracts and the papers were published in the Proceedings of the 25th International Geological Congress, 1972.

1974. Golden Sands — Varna, Bulgaria. 13 papers presented by specialists from 5 countries were discussed, the abstracts were published in a special volume of the IAGOD Symposium, and the papers are to be published in the Proceedings.

1976. Sydney, Australia. 36 papers presented by geologists from 13 countries were discussed. The abstracts were published in the volumes of the 25th IGC, the extended numbers of papers will be published in the International Monograph — the Proceedings of the 2nd Symposium on Geology and Geochemistry of Manganese.

However, along with the evident achievements of the Commissions activity there are some shortcomings. It seems that the work of some national representatives of the Commission should be more active. It was noted that such important producers of manganese as countries of Africa and South America, have not yet been represented in the Commission by National Representatives.

3. The participants of the Meeting adopted the proposal to ask the head of the Brazilian National Committee for Geology and the head of the University of Sao Paolo to support the nomination of Dr. Evaristo Ribeiro Filho (University of Sao Paolo, Brazil) as a National Representative in the Commission on Manganese.

4. The participants, and especially the members of the Editorial Board of the Monograph were informed on the progress in preparation of the materials for publication.

Gy. Grasselly and I. M. Varentsov made the explanations about the development of relations between the Publishing House of Hungarian Academy of Sciences and the Editorial Board of the Monograph. After an attentive consideration of the conditions of the work of the Editorial Board (the memo by Varentsov of July 1, 1976) the present associated editors confirmed their inttention to work on the processing of the manuscript.

It was decided after the discussion that the appropriated deadline of presentation of all the processed papers to the Publisher may be the end of 1976. This deadline is somewhat conditional as it can be kept if the Publisher could complete all the formalities to guarantee the proper fulfilment of the conditions of the agreement on publication of the Monograph.

5. I. M. Varentsov informed the participants about the further plans of the Commission. It was stated that after realization of the main tasks: the organization of the 2nd International Symposium on Geology and Geochemistry of Manganese, the 25th IGC, 1976, Australia, and the publication of the International Monograph — the Proceedings of the Symposium, the activity of the Commission should develop in the two chief aspects: a) Participation and co-ordination of the work on the Project: Genesis of Manganese Deposits, International Programme of Geological Correlation; b) To carry on the traditional forms of the Commission's activity on wide information of the specialists on different areas of geology of manganese and associated metals, as well as the work on the international co-operation of the investigations.

The proposal was adopted to hold the next session of the Commission (Technical and Business Meetings) within the forthcoming IAGOD Symposium, 1978, Salt Lake City, USA.

6. *The election of Vice-President*

I. M. Varentsov, Secretary of the Commission informed that John Van N. Dorr II (Geological Survey, Washington, D. C., USA), the former Vice President retired in 1975. J. V. N. Dorr II told the Officers of the Commission about his wish to resign the duty of Vice-President of the Commission. The officers of the Commission complied with J. V. N. Dorr's request, and, bearing in mind his long and fruitful service for the manganese geologists of the Western Hemisphere, suggested him to accept the post of Honorary Vice-President of the Commission.

I. M. VARENTSOV informed the participants of the proposal made by D. S. CRONAN (U. K.) to nominate on the post of Vice-President R. K. SOREM, Professor of the Washington State University (Pullman, USA). The U. S. A. were said to be a country of advancing researches on wide aspects of geology, geochemistry and mineralogy of manganese and associated metals, and that this Nation could be represented in the Commission at a high level. R. K. SOREM is a prominent scientist in mineralogy and geology of manganese whose works are well known in the world.

The proposal about nomination of R. K. SOREM on the post of Vice-President of the Commission was supported by D. S. CRONAN (U. K.), K. BOSTRÖM (Sweden), R. G. BURNS (USA) and others.

In response, R. K. SOREM expressed his gratitude to the participants for the honour and said that he, as Vice-President, would do all hist best for realization of the Commission plans and strengthen the international co-operation.

7. *Discussion.* The participants of the Meeting adopted the activity of the Commission on Manganese. They noted the significance of the 2nd International Symposium on Geology and Geochemistry of Manganese and publication of the International Monograph — Proceedings of the Symposium. Professor T. WATANABE (Japan), Past President of the International Association on Genesis of Ore Depoits expressed his appreciation and gratitude to the Commission's Officers for the work done. T. WATANABE emphasized that the activity of the Commission on Manganese could be regarded as a model of its scientifical and practical importance, as well as the organization of highly efficient international collaboration of the scientists and specialists of different Nations of the World.

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Felelős kiadó: Dr. Grasselly Gyula
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az MSZ 5601—59 és 5602—55 szabvány szerint.
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